FIELD SAMPLING PROCEDURES GUIDANCE MANUAL

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Revised October 2001

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1.1 Introduction

The New Hampshire Department of Environmental Services (NHDES) has prepared this Field Sampling Procedures Guidance Manual to provide field-sampling protocols for site investigations and monitoring activities at contaminated sites. The manual details a variety of techniques for sample collection from various matrices: soil, surface water, groundwater and air. Topics related to sampling techniques such as personnel protection, decontamination, and portable instrumentation (i.e., field screening) are also included.

The material presented in this manual represents guidance prepared by NHDES and does not replace specific requirements contained within NHDES rules. Rules, which may prescribe certain sampling activities or methods unique to a particular program, site, or matrix, have legal precedence over this manual.

1.2 Purpose

This manual seeks to promote consistency in the public and private sector in the manner in which samples from contaminated sites are collected for analysis. The validity of the analytical data obtained from sampling is dependent on the integrity of the procedures employed in field screening, obtaining samples for analysis, and the laboratory techniques used to qualify and quantify the compounds of concern. The methods and procedures described here are intended for use by individuals involved with any contaminated site requiring chemical, physical, and/or biological analysis of samples for site investigation and monitoring purposes. Because this document represents field-sampling programs throughout the NHDES, any site and/or regulatory specific issues regarding field sampling or laboratory techniques must be discussed with applicable program personnel.

For each matrix (e.g., air, soil, surface water, and groundwater), several different sampling procedures are provided and several methods for storage, preserving, and analyzing a sample are also presented. Each procedure or method may be scientifically correct under site or matrix specific circumstances but some methodologies presented may not be applicable to specific site situations. A certain procedure, though included, may be disallowed at the discretion of NHDES program personnel if deemed inappropriate in a particular situation.

While a large number of field screening instruments are available, only a small number are commonly used. The ease and the reliability of the instruments used are probably the major factors determining which instrument is chosen. This manual focuses on the most common ones; all of which are accepted by the NHDES. NHDES should be contacted before using instrumentation or technologies not included in this manual.

Environmental sampling, which for the purposes of this manual includes the collection, field screening, preservation, storage and analysis, inherently presents many variables, which may ultimately affect the outcome of the results. Since the nature of environmental sampling requires the analysis of a small aliquot of bulk material, proper techniques must be employed to obtain a sample, which retains its scientific integrity and is legally defensible and representative of the contaminants present.

To meet these conditions, a sample must be collected and handled (i.e., stored and preserved) so as to maintain, to the greatest possible extent, its original physical form and chemical composition. For a sample to represent a larger body of contamination in question, it is imperative to assure sample integrity and maintain quality assurance standards in the field. The sampling procedures put forth in this manual are designed to minimize the possibility of altering sample integrity.

The achievement of consistency in sampling procedures and techniques helps ensure the data obtained has acceptable quality, comparability, and usability. The importance of data quality has been recognized through stringent lab quality assurance/quality control (QA/QC) programs. This manual is intended to compliment those procedures by establishing appropriate QA/QC during sample collection in the field. Quality assurance (QA) measures coupled with a site specific sampling plan will improve the probability of collecting representative samples. This is important to ensure that public and private monetary resources are utilized in an effective manner.

The ultimate purpose of performing accurate and precise sampling is to assist in remediation at sites and return contaminated soil, groundwater, surface water, and air to acceptable levels. The most common contaminants found in contaminated sites and their targeted cleanup levels are listed in the NHDES Risk Characterization and Management Policy 1998 (RCMP) and revised April 2001.

1.3 Field Sampling Plan

General field sampling plans (FSPs) are routinely used in the environmental consulting community. However, there is an increased interest in developing and using site specific FSPs to assist in conducting site investigations (SI) and other phases of site work in a more timely, uniform and cost effective manner at contaminated sites. For owners of petroleum contaminated sites seeking reimbursement from the New Hampshire Petroleum Reimbursement Funds, the information in a site specific FSP must be incorporated in a Work Scope for any phase of a site project requiring sampling. The site specific FSP shall contain ***only*** those features unique to the site. For non-fund eligible contaminated sites, including hazardous waste sites, a site specific FSP shall be submitted when requested by a NHDES project manager. This manual is intended to assist the environmental community in developing both general and site specific FSPs.

The general FSP should contain the following information:

- Maintenance procedures for all field instruments
- Calibration procedures for all field instruments
- Description of field QA/QC procedures
- Sample collection preservation procedures
- Decontamination techniques
- Record keeping procedures
- Tables presenting analytical holding times, methods

The site specific FSP should contain the following information which can be incorporated as part of a work scope or a stand alone FSP:

- Site background information
- Summary of contaminants of concern and proposed analytical methods
- Map(s) indicating proposed sampling locations
- Brief rationale for selection of sampling points
- Sampling tools, methods and container types

To make the site specific FSP more useful in the field, it should be written as a short and concise document and should utilize summary tables whenever possible. If fieldwork is to be performed in several phases, a separate or modified site specific FSP may be required for each phase. The term "phase" refers to the five phases of site work at contaminated sites: Initial Response Action (IRA), Site Investigation (SI), Remedial Action Plan (RAP), Remedial Plan Implementation (RPI), or Groundwater Management Permit (GMP).

1.4 Field Sampling Objectives

The following is a list of objectives that may apply to any field sampling program, depending on the situation at a site.

a. Determine the potability of a private or municipal water supply well
Private or municipal water supply wells serve 80% of New Hampshire residents. If there is a potential threat to a well at or near a contaminated site, an evaluation of the water supply may be necessary.

b. Determine air quality of inhabited areas
Volatile Organic Compounds (VOCs) vapor and gases typically associated with releases from contaminated sites can migrate from groundwater to indoor air. Therefore, sampling and monitoring may be necessary to assess the potential adverse impacts to air quality.

c. Determine the presence of potentially explosive organic vapors

Because of the nature of VOCs or gases, they may become explosive under certain conditions. Monitoring for the presence and concentration of explosive vapors and/or gases from a contaminated site protects site workers and the general public.

d. Identify source areas

The first phase in remediation is to locate and remove/remediate the source of contamination. Field screening is used to locate all possible sources of contamination at a site.

e. Delineate a contaminant plume

To determine if remediation is necessary and to optimize the design of a remedial system, it is necessary to evaluate the nature and extent of potentially contaminated groundwater in a timely manner.

f. Evaluate hydrogeologic characteristics of the aquifer(s)

An understanding of an aquifer's hydrogeologic characteristics (i.e., gradient, permeability, transmissivity, conductivity) assists in establishing recovery methods, locations and possible treatment scenarios.

g. Determine the presence/absence of contamination in soils and groundwater during excavation using field screening techniques and subsequent laboratory analyses

Field screening techniques allow for determining the presence or absence of contaminated soils or groundwater from real time data. Subsequent lab analyses are performed to confirm field screening results. See *h*. below.

h. Determine the extent of excavation of contaminated soil with confirmation of field screening results by laboratory analysis

Field screening techniques are used to segregate contaminated and clean soil and to establish the limits of contamination. Subsequent laboratory analyses are performed on samples taken from the walls and floor of the excavation to confirm field screening results.

i. Evaluate the extent of contamination in surface water

Contaminants move quickly in the surface water, increasing the risk to downstream receptors utilizing that water. Surface water contamination must be determined quickly to assure protection of human health and the environment.

j. Monitor remedial systems

To verify the effectiveness of remedial systems, real time data from field screening techniques can be used. Therefore, adjustments can be made in the operation of the system almost instantly without waiting for laboratory results.

k. *Monitor remedial performance standards*

The performance of remedial systems needs to be monitored to determine if the desired objectives (i.e., target cleanup levels achieved, protection of human health and the environment) have been attained.

Chapter 2

Sampling Strategies

2.1 Introduction

The purpose of this chapter is to provide guidance for the development of a sampling program for contaminated sites. In developing a sampling strategy, it is important to identify the objectives and constraints of sampling. The guidance presented here follows the assumption that the primary objective of sampling is to characterize the nature and extent of contamination and the primary constraint is cost.

Adequate site characterization is pivotal for selection and design of remedial strategies. Consider, for example, the selection of soil excavation as a remediation strategy based on a poor estimate of spatial extent. If the contamination is significantly more widespread than initially estimated, the expense of excavation could greatly exceed the design, installations and operation of a remediation system.

In addition to estimating the spatial extent of contamination, it is necessary to estimate the concentration of contamination present. Since some remediation techniques may require several years, it is often desirable to assess the performance of the remediation. For these cases, it is important to make a reasonably accurate estimate of the initial concentration of contaminants in place.

Each site is unique in its hydrogeology, type of contamination, constraints of characterizations and remediation, and type of site conditions. The hydrogeologic setting may be stratified drift, glacial till, and/or bedrock. Contamination may consist of petroleum products or hazardous waste substances. Since each of these characteristics play a large role in developing an optimal sampling strategy, it is necessary to develop a suite of strategies for several general cases. It is also anticipated the recommendations outlined here may need to be modified for some sites. For this reason, the concepts are outlined as they pertain to the sampling strategies developed.

The basic concepts of sample strategy design are presented followed by recommended sampling strategies for four generic scenarios: 1) contaminated soil with an unknown source; 2) contaminated soil with a known source; 3) contaminated groundwater with an unknown source; and 4) contaminated groundwater with a known source.

The reader is referred to Gilbert (1987) for more in-depth discussion of the concepts covered here and it should be recognized that no single sample design is optimal for all cases.

2.2 Concepts of Statistical Sampling

In designing sampling strategies it is necessary to clearly define the objectives, constraints, and decision variables of the sampling. In the context of contaminated soils, the two primary objectives are the estimation of the spatial extent of contamination and the total concentration of contaminants in place. Constraints are often the cost of sampling, the desired accuracy of the estimate, and the acceptable probability of missing a lens of contamination. The decision variables are usually the number of samples and the sample location.

Determining the decision variables (number of samples and sample location) based on the objectives and constraints usually relies on simple statistical models of the spatial distribution of contamination. For example, a common model for the spatial distribution of contamination is an uncorrelated random field. The uncorrelated random field model assumes the concentration at each location is a realization of a random variable and the spatial set of random variables are statistically independent of one another. By adopting such a model, it is then possible to determine the number of samples necessary to estimate the mean with a specified level of certainty and/or subject to other constraints such as cost.

While the uncorrelated random field model is frequently used and adopted here due to its simplicity, it is probably not the most accurate model of the spatial distribution of contamination. The model assumes that concentrations are spatially independent and there is not a trend in the concentration values. In reality, concentrations are usually spatially correlated in that high levels of concentration tend to be located near other high levels of concentration. Similarly, the concentration data usually reflect a spatial plume with highest concentrations near the center and decreasing toward the edges. These discrepancies between the model and reality inhibit the accuracy of the relationship between the number of measurements and the uncertainty in the estimates. However, since alternative methods require definition of the spatial correlation and trend they are data intensive and site specific. Provided the investigators bear in mind the discrepancy between the model assumptions and actual site conditions, the uncorrelated random field model will provide a reasonable means of determining the samples subject to constraints.

Another common model, and one that is adopted here, is that contamination occurs in randomly distributed lenses. These randomly distributed lenses are referred to as hot spots. A hot spot is defined as any region that exceeds some threshold concentration. In addition to a threshold concentration, hot spots are characterized by their geometric properties of shape and size. The shape is often assumed to be circular or elliptical and the size is the dimension of the long axis.

For the purposes of this manual, hot spots are assumed circular in the horizontal plane and elliptical in the vertical plane. The threshold levels of contamination are the concentrations listed in the NHDES RCMP.

The hot spot sampling strategy provides a means of determining the recommended spacing of soil borings for defining the spatial extent of soil contamination. In determining the spacing between samples, four parameters are necessary: 1) the assumed shape of the hot spot; 2) the smallest size of the hot spot of interest; 3) the level of confidence in detecting the hot spot; and 4) the probability the hot spot exists (usually equal to one).

In this manual, the two main objectives of estimating the spatial extent and concentration of contaminant in place are considered separately, each with different decision variables subject to different constraints. The sampling strategy for estimating spatial extent follows the hot spot model while the sampling strategy for estimating the concentration of contaminant in place follows the uncorrelated random field model.

2.3 Hot Spot Sampling

Hot spot sampling is adopted in this manual as the recommended means of determining sample spacing. Given the inherent complexity in estimating the spatial extent of non-aqueous phase liquids (NAPLs) and their soluble derivatives in heterogeneous soils, the complex physical and chemical processes, and the uncertainty in total volume released and time since the release, the location of the contamination closely approximates the random model utilized in the hot spot strategy.

2.4 Recommended Sampling Strategies

Introduction

Sampling strategies are recommended both for soil and groundwater at contaminated sties. The recommendations are subdivided into two phases of site investigation. The first phase is the Initial Response Action (IRA) / Initial Site Characterization (ISC) in which the primary objective is to locate release locations and the source of contamination. The IRA/ISC phase follows largely a *deterministic sampling* strategy in that samples are taken at specified locations with regard to the potential sources. Sampling strategies for the second phase, the Site Investigation (SI) phase follows *probabilistic sampling* algorithms in which there is much more uncertainty in the location and amount of contamination.

For soils and groundwater contamination, two situations are considered: an unknown source and a known source. For situations where contamination has been encountered but the source is unknown, one of the objectives of the IRA/ISC is to identify the potential source(s). In the situation when the general source of contamination is relatively certain (e.g. contamination encountered beneath an underground storage tank (UST), a UST fails a pressure test, or buried drums of hazardous waste), the source is considered known.

The objectives of the SI are to estimate the spatial extent and concentrations of contaminant in place for the purpose of selecting and designing a remediation strategy. It is assumed the source(s) have been identified from the IRA/ISC phase.

2.4.1 Soil Contamination

Introduction

Soil is one of the initial environmental media that has to be adequately characterized in order to develop a full understanding of the nature and the extent of environmental contamination at a site. Knowledge of where contaminated soil is located is critical to the appropriate placement of monitor wells, which results in the appropriate monitoring of the groundwater. Adequate characterization of the contaminated soil also aids in determining the source of the contamination.

Unknown Source/IRA/ISC Phase

The situation of soil contamination with an unknown source is one in which contamination is known or suspected to exist. The primary objective of the sampling is to define the release location and provide initial information for the subsequent SI phase. The IRA/ISC sampling does not provide adequate information for the delineation of the spatial extent of contamination or the concentration of contaminant present.

Upon identification and removal of suspected leaking Underground Storage Tanks (USTs), or buried drums, samples should be collected from directly under and at each end of the UST or buried drum area. Additional samples should be collected at 20 foot intervals along pipes, at pipe elbows, under distribution facilities (pumps), and where hazardous waste was discharged to the ground.

Known Source/SI Phase

If soil contamination is found at the site during the IRA/ISC phase, it is then necessary to obtain additional information for the design of remedial actions. The three most important considerations are: 1) the spatial extent of contamination, 2) the concentration of contaminant present, and 3) the hydrogeology of the site. Defining each of these factors requires different types of samples. Delineation of the spatial extent alone requires a minimum of filed screening, and for non-volatile contaminants, laboratory analyses. Estimation of the concentration of contaminant in place requires laboratory samples and characterization of the site hydrogeology requires geologic samples. While each of these factors should be considered in the SI, different sites will require different allocations of sampling.

Spatial Extent

One objective of sampling is to assess the spatial extent of contamination and delineate the plume boundaries. Both over-excavation and soil borings can be used to assess the spatial extent of contamination.

Over-excavation is defined as excavation beyond that required for removal of the source area and should follow OSHA sloping requirements. Over-excavation may be appropriate for small sites in which the contamination is relatively shallow (within reach of a backhoe). It is not appropriate for large sites in which an excessive amount of soil is contaminated or the contamination extends below surface structures such as building foundations. Arrangements should be made for soil treatment and/or disposal prior to excavation. Follow current NHDES practices for disposal of drill or hand auger cuttings or test pit samples on site.

An alternative and/or supplement to over-excavation are the use of soil borings to delineate the spatial extent of contamination. Soil borings are useful for large sites or those in which the contamination may be widespread both vertically and horizontally.

The recommended spacing of soil borings for defining the spatial extent of contamination is based on the following criteria: 1) the shape of the hot spot and 2) the size of the hot spot. The total of the grid and thus the total number of soil borings should be determined from the IRA/ISC/SI and the region over which there is believed to be a finite probability of contamination. Factors to consider include estimated volume of release, time since release first occurred, and barriers to vertical flow. Each of these will potentially contribute to enhanced lateral migration in the soil zone. Soil type may not be a good indicator of lateral extent due to the complex physical processes of multi-phase flow through heterogeneous media.

It is important to bear in mind that soil borings that do not exhibit contamination provide valuable information for plume delineation. Similarly, locating wells in such a manner to "find" contaminants does little to advance the delineation of the plume. Objective sampling on a square grid provides an unbiased estimate of the extent of contamination as well as quantifiable probabilities that an existing hot spot was missed.

The recommended pattern of soil borings is shown in Figure 2.1. The procedure for delineating the spatial extent of contamination is as follows:

1) Conduct IRA/ISC and determine location of major release.

2) Establish a nine-point grid with modal spacing of 20 feet centered over principal release.

3) For Light Non-Aqueous Phase Liquids (LNAPLs) contamination, auger to water table at each of the grid locations sampling soil vertically every 5.0 feet or less depending on site conditions using field screening techniques, collecting samples for laboratory analysis, or both. The sampling technique selected should be able to detect the presence or absence of contamination as described in Chapter 3. If the estimation of the concentration of contaminant in place is a sampling objective, refer to page 6. Monitoring at greater depths may be necessary depending on the nature of the contaminant, i.e. Dense Non-Aqueous Phase Liquids (DNAPLs).

4) If contamination is not encountered in the perimeter soil borings, the site can be considered adequately characterized for hot spots.

5) If contamination is encountered in one of the perimeter soil borings, establish an additional four-point grid with 20 foot spacing to include the perimeter boring with contamination (Figure 2.1a). Contamination in two perimeter borings will require a combination of the supplemental sampling described above depending on where the contamination occurs (Figure 2.1b).

Figure 2.1
Soil Boring Sample Grid

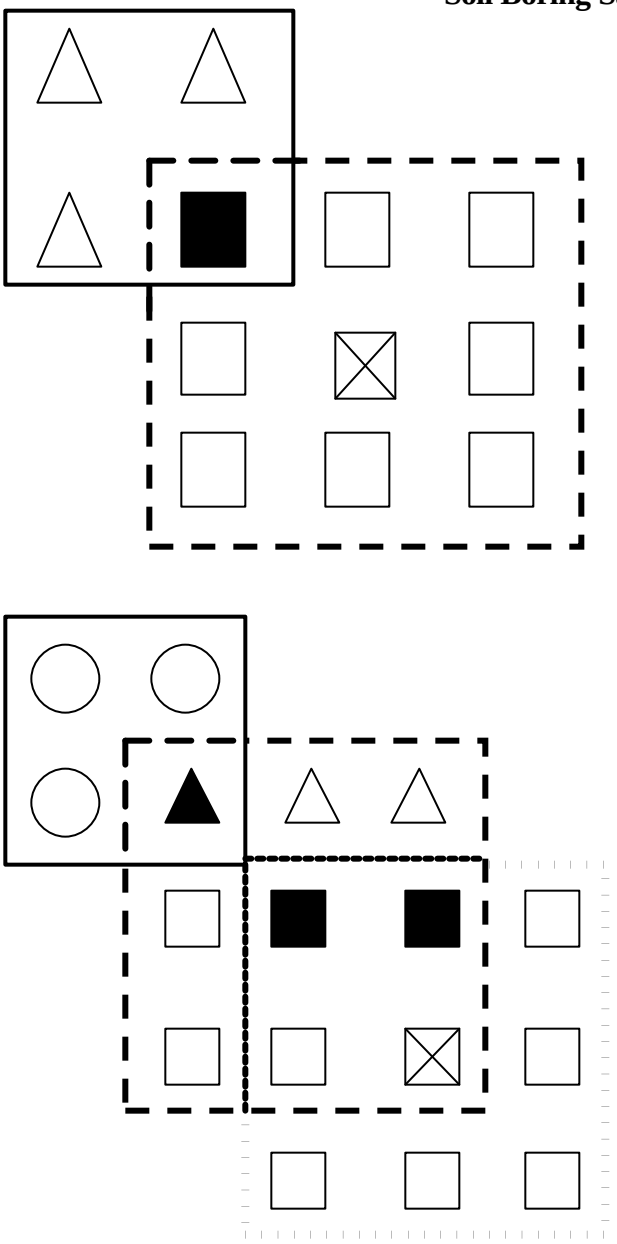
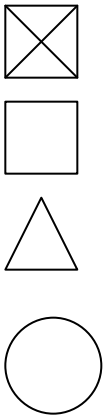


Figure 2.1a Schematic diagram of soil boring locations for a case when one perimeter boring of the original nine detects contamination.



Location of primary leak

Boring locations for initial nine-point grid

Boring locations for first supplemental sampling

Boring locations for second supplemental sampling

Filled symbols denote contamination encountered.

Figure 2.1b Schematic diagram of soil boring locations for a case when two perimeter borings of the original nine detect contamination and one perimeter boring of supplemental grid detects contamination.

6) Evaluate results of Step 5. One approach would be to construct a plan view map of maximum concentrations found in each boring. If any of the concentrations exceed those listed in the NHDES RCMP, a hot spot is present at that location. Next, construct cross section(s) through the borings that contain hot spots. Map the hot spots as a function of depth. If additional contamination is encountered in the supplemental sampling, an additional round of sampling may be necessary to determine the extent of contamination (Figure 2.1b). Use the same criteria as outlined in Step 5.

   The grid dimensions determined from the method above define the horizontal spacing of samples. A similar approach can be used for the vertical spacing of samples, however it is recommended that either; 1) continuous screening is performed on drill or hand auger cuttings or 2) analytical samples be collected every 5.0 feet. Vertical sampling should extend to the water table with a sample collected near the water table elevation.

   When DNAPLs are suspected, appropriate EPA test methodologies that include several of the more common DNAPLs such as methylene chloride, chloroform, trichloroethane, tetrachloroethylene and 1,1,1-trichloroethane would need to be used for soil samples collected at or near the water table. The appropriate EPA test method for DNAPL is 8260B.

Estimation of Volume and Mass of Contaminant in Place

Unlike the delineation of the spatial extent of the contaminant plume, estimation of the mass of contaminant in place requires the estimation of the mean contaminant concentration. A simple estimate of the total contaminant in place is then the mean concentration multiplied by the volume of contaminated soil. Such estimates may be important for remedial design and/or subsequent performance assessment.

Field screening devices such as Photo Ionization Detectors (PIDs) and Flame Ionization Detectors (FIDs) that measure only total VOCs may not be adequate for this purpose. Compound-specific analyses, accomplished by the use of gas chromatography/mass spectrometry (GC/MS) are usually required for estimation of amount of contaminant in place.

The number of samples taken is site specific. Efforts should be made to evaluate a representative number of samples with both field screening and laboratory methods.

The mass of contaminant in place (M_{total}) can be estimated by calculating the mean concentration (kg/kg) from the field and/or laboratory data for each zone of contamination and then multiplying the average concentration by the estimated mass of contaminated soil (kg). The mass of contaminated soil is calculated from the soil bulk density (kg/l) and the bulk volume of contaminated soil (l^3). HS refers to hot spot. (See equation)

$$M_{total} = \sum_{t=1}^{p} \overline{C} \, M_{HS}$$

As an example, suppose the hot spots are assumed to be circular in plan view with a 12 foot diameter and rectangular in cross-sectional view with a thickness of 4 feet. The mass of contaminated soil is then the volume of the hot spot times the bulk density:

$$= (2 \times \pi) \times r^2 \times b \times \rho_b$$

$$= (2 \times \pi) \times 36\ ft^2 \times 4ft \times 1200 kg/m^3 \times 2.932 \times 10^{-2} m^3/ft^3$$

$$M_{HS} = 3.07 \times 10^4\ kg$$

The amount of contaminant in place can be estimated by multiplying the mass of contaminated soil in each hot spot by their respective average concentrations. If two hot spots were identified with an average concentration of 1×10^{-4} kg/kg and the other with a concentration of 2×10^{-5} kg/kg, the total mass of contaminant in place would be approximately,

$$M_{total} = C_1 M_{HS1} + C_2 M_{HS2}$$

$$= (\{1x10^{-4}\ kg/kg\} \times \{3.07 \times 10^4\ kg\}) + (\{2 \times 10^{-5}\ kg/kg\} \times 3.07 \times 10^4\ kg\})$$

$$M_{total} = 3.68\ kg$$

Reporting Requirements

The following should be included in the sampling section of final IRA/SI reports:

1. A description of sampling methodology and analytical field screening methods.
2. Measurements presented in tabular format
3. Laboratory analytical data presented in tabular format
4. Plan-view and cross-section maps of hot spots
5. Estimation of volume of contaminant in place, if applicable

2.4.2 Groundwater Contamination

If during the soil investigation program, contamination is identified above applicable regulatory standards, a groundwater investigation is required. The purpose of the groundwater investigation is to assess groundwater quality to determine if a violation of Ambient Groundwater Quality Standards (AGQS) exists. The investigation shall determine the location and full extent of contamination and identify receptors and potential receptors. The investigation shall be performed in accordance with Env-Wm 1403.07 Site Investigation.

The sampling strategies for delineating the nature and extent of groundwater contamination must consider the behavior of the contaminant(s) within the aquifer. There are two primary categories of organic fluid behavior within an aquifer system: LNAPLs (floaters) and DNAPLs (sinkers). LNAPLs are less dense than water and if present in separate phase, will float on top of the water table. Once separate or dissolved phase LNAPL is present within the aquifer system, it can move rapidly in the direction of groundwater flow. DNAPL compounds are denser and typically less viscous than water.

Once DNAPL reaches the water table, it may continue to migrate downward until the mobile DNAPL is exhausted or until low permeability stratigraphic units are encountered which create free phase DNAPL accumulation zones (DNAPL pools) in the soil aquifer matrix. DNAPL introduced into a fractured rock or a fractured clay aquifer system follows a complex pathway based on the distribution of fractures in the matrix.

The groundwater investigation is typically conducted in a phased approach. Prior to installing a permanent monitoring well network, an analysis of the site should be completed to, 1) establish a conceptual hydrogeological model for the site, 2) establish hydraulic conductivity for the aquifer unit(s) (using field tests and/or laboratory tests), 3) construct a groundwater flow net, and 4) locate property boundaries and waste disposal areas.

Evaluation of Hydrogeologic Conditions

A significant control on contaminant migration once it reaches the saturated zone is the hydrogeology of the site. Therefore, the hydrogeologic evaluation, at a minimum, should include the following information:

1. Aquifer type: stratified media, glacial till, bedrock, etc.
2. Hydraulic conductivity, hydraulic gradient/and flow direction.
3. Depth to lowest aquitard or aquiclude.

For relatively simple homogeneous aquifer systems (single aquifer) the monitoring program should define the hydrogeologic conditions in the formation in which the contamination exists. For complex aquifer systems (multiple aquifers) the monitoring program may need to be expanded to define hydrogeologic conditions within each aquifer underlying the site.

The U.S. Geological Survey has been in the process of compiling the hydrogeologic conditions of surficial deposits throughout New Hampshire. This series of Water Resources Investigation Reports is one reference that should be consulted for sites where coverage exits. Other reference materials include: U.S. Geological Survey Topographic Maps; USDA Soil Conservation Service Soil Survey Maps; NH Division of Resources and Economic Development Structural Geologic Maps, aerial photographs, etc.

Conceptual Model

The information gathered during the evaluation of the contaminants and the hydrogeology shall be compiled, interpreted and organized into a conceptual model. The conceptual model shall describe the occurrence and movement of groundwater at the site and provide a technical explanation of the nature and extent of contamination in the soil, surface water, and groundwater. The model shall identify the pathways of contaminant migration, transport mechanisms, and potential receptors, taking into consideration all available geologic, hydrogeologic and contaminant distribution data. The model will form the basis for decisions regarding the site including configuration of the monitoring well network, the remedial program, Groundwater Management Zone (GMZ) delineation, and ultimate site closure.

Monitoring Wells

The groundwater monitoring system should consist of a sufficient number of monitoring wells to define the nature, extent and magnitude of contamination and identify potential threats to human health and the environment. The monitoring well network should be designed to assess groundwater quality both up gradient and down gradient of the suspected or known source area(s). Typically, one monitoring well should be installed up gradient and at least three wells should be installed hydraulically down gradient of the suspected or known source area. However, the number of wells required to adequately monitor a specific site will vary greatly, depending on a variety of factors including but not limited to the physical characteristics of the contaminant(s), hydrogeologic conditions, the nature and extent of the source area, and potential receptors.

For sites where the source of contamination is known, the optimal locations for the placement of monitoring wells are at the midpoint of plume migration and at each edge of the plume. If stratigraphy and/or contaminant behavior suggest vertical flow, installation of monitoring well clusters may be necessary. Figure 2.2 presents a simplified groundwater monitoring system for a site with a known source using a phased approach.

For sites where groundwater contamination has been encountered but the source is unknown, it is necessary to install wells to delineate the extent of contamination and identify potential source(s). The first step in determining monitoring well location is to identify potential up gradient sources. This is typically performed by using a combination of the hydrogeologic information and information on usage of nearby properties.

Once potential sources are identified, monitoring wells should be installed down gradient of the potential sources (up gradient of the receptor) as shown on Figure 2.3. This should be conducted in a phased approach with the most likely source(s) tested first. However, if one source is identified initially, it does not rule out the potential for additional sources.

For most LNAPL sites, monitoring wells are typically designed so that their screened interval intersects the water table (the location where separate-phase floating product could be encountered). At DNAPL sites, monitoring wells should be designed so that their screens intersect the bottom of the aquifer zone at the confining layer where separate-phase might be encountered. Presuming the source of DNAPL is at or near the ground surface and that residual DNAPL is present in the vadose zone/near the water table, water table wells are installed initially and then deeper wells are subsequently installed near sources/areas of highest concentrations. Well clusters may also be necessary to monitor contaminant concentrations at multiple depths within a single or complex aquifer system. Special precautions must be taken to ensure that drilling does not create pathways for vertical migration of free-phase DNAPL. The potential for remobilization of DNAPL along borings may be reduced by not drilling in areas known or suspected to be DNAPL zones.

During drilling, soil samples are typically collected every five feet or at any detected changes in stratigraphy. Soil samples should be screened in the field for VOCs and Polyaromatic Hydrocarbons (PAHs) using field screening techniques, such as, Gas Chromatography (GC) headspace analysis, flame ionization detector (FID) headspace analysis or photo ionization detector (PID) headspace analysis. Based on the screening results, one soil sample from each boring should be collected from the soil sample with the highest VOC reading. Collection of additional soil samples may be necessary based on site-specific conditions. If no VOCs are detected, the sample shall be taken at the water table. Detailed geologic logs should be prepared for each boring. Refer to Chapter 3 for more details.

If the contamination is in fractured rock, the anisotropy of the hydraulic conductivity is controlled by the fracture orientations and may play a significant role in controlling the direction of contaminant migration. When fractured rock is the primary medium of transport, additional studies of fracture patterns in nearby outcrops (if present) should be performed. Note in particular the horizontal and vertical orientation of the fracture set(s).

Monitoring wells may be constructed by a variety of drilling methods, some of which may be better suited to a site than others. Wells shall be properly developed to remove fines and ensure groundwater movement into the well. Note that Env-Wm 1403.27 Groundwater Monitoring Wells, requires that monitoring wells be designed, installed and decommissioned in accordance with the practices described in 1) Standard Practices for Design and Installation of Groundwater Monitoring Wells in Aquifer." American Society for Testing and Materials, Designation: D 5092-90, approved June 29, 1990, and published October 1990, and 2) Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells, document identification number EPA/600/4-89/034, United States Environmental Protection Agency, March 1991. Env-Wm 1403.27 also requires that monitoring wells be constructed and decommissioned only by licensed New Hampshire water well contractors holding a valid technical drillers license under RSA 482-B.

Figure 2.2
Schematic Diagram for Well Locations with Known Source (Phased Approach)

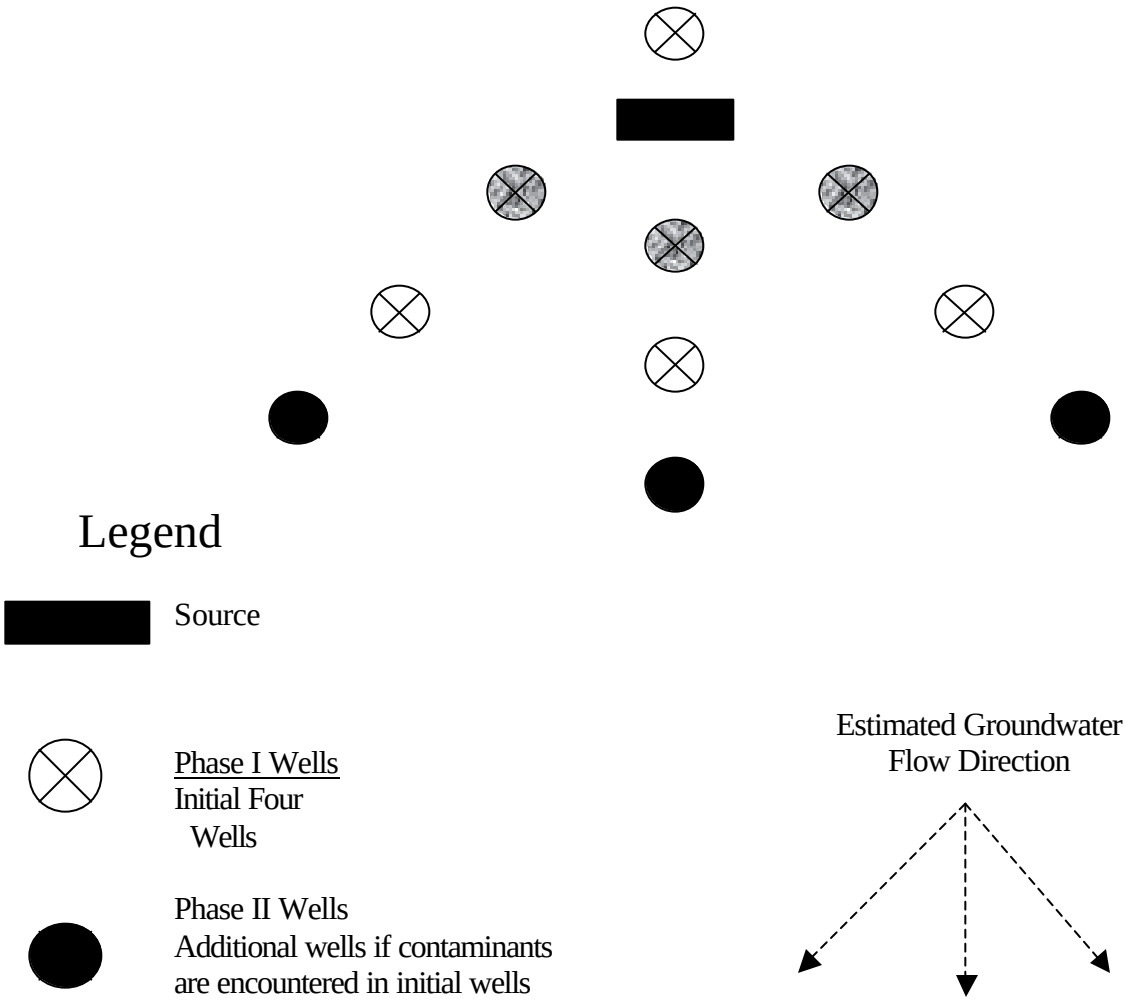
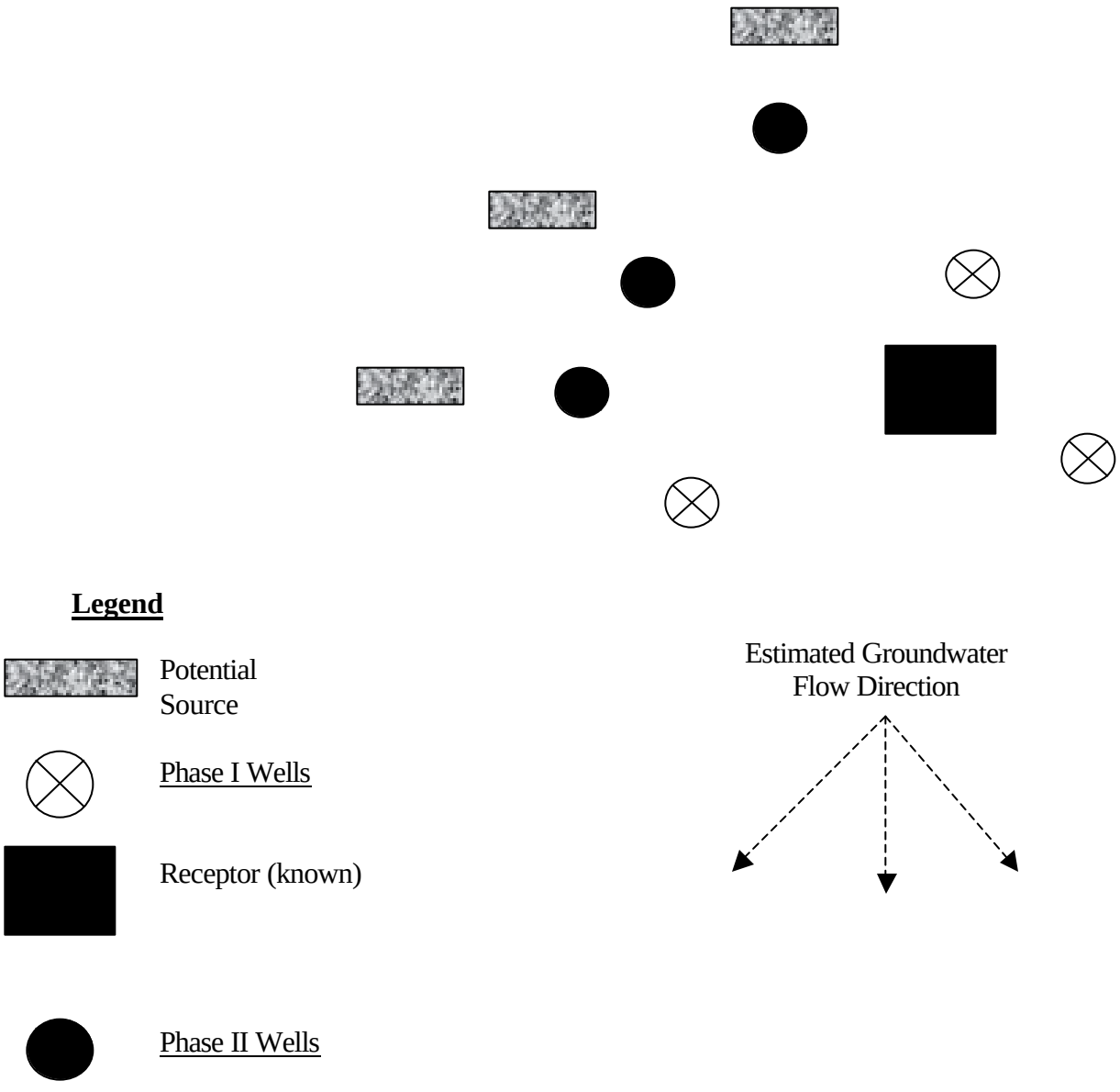


Figure 2.3

Schematic Diagram for Well Locations With Unknown Source (Phased Approach)



Chapter 3

Field Screening Procedures

3.1 Introduction

Field screening procedures are necessary to provide rapid and accurate field measurements of various contaminants. Normally, assessments of environmental contamination at contaminated sites required several weeks of waiting to receive results from an analytical laboratory. The incorporation of field screening techniques at these sites can dramatically reduce the time required to acquire data and provide for greater resource protection of soil, groundwater, and surface water.

3.2 Purpose

There are many reasons why field screening is used at contaminated sites. From health and safety issues to system monitoring, field screening is invaluable in helping remediate a site in a timely and cost effective manner. The main reasons for performing field screenings are discussed below.

Health and Safety

The most important reason for field screening is to safeguard employees. Use of field screening procedures is extremely important to help initially survey the site for health and environmental hazards. Specific details on assuring employee health and safety are beyond the scope of this manual and are covered under the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) regulations (40CFR Part 1910.120) which should be consulted.

Source Identification

NHDES encourages the use of field screening techniques to determine if contaminants are present in the site soil, air or water in the vicinity of potential source areas, i.e., screening soil beneath an UST or buried drum area.

Contamination Delineation

During the IRA/ISC/SI phase of site work, field-screening techniques can be very useful to delineate vertical and horizontal extent of soil contamination. Once the boundaries have been established, applicable remedial measures may be discussed, locations for soil borings/monitoring well installations can be proposed, and excavation limits, if applicable, can be presented.

Remedial System and Discharge Permit Monitoring

Field screening techniques can be used to monitor the effectiveness of a treatment system by screening the influent and effluent. Field screening methods eliminate the waiting period for the turnaround time for fixed laboratory results. Waiting days for laboratory analytical data can slow the site cleanup process.

Soil Segregation/Stockpiled Soil Characterization

Field screening methods are used to categorize whether soil or backfill surrounding a source is "clean" and can be returned to the excavation or require treatment. Field screening techniques must be used correctly and accurately. If improperly used, vast quantities of soil incorrectly labeled as contaminated may be remediated at a substantial cost. The opposite also holds true. If large quantities of contaminated soil, incorrectly labeled as "clean," are returned to the excavation, contamination may continue to migrate.

UST Closure

Closing of Leaking Underground Storage Tank (LUST) sites necessitates the use of field screening techniques to effectively and efficiently monitor the soil, air, and water during and after the UST closure. Immediate real time field screening data is crucial for obtaining representative environmental samples for subsequent laboratory analysis.

3.3 Field Screening Techniques

Headspace Analysis

Headspace analysis is a field screening procedure involving the collection of a soil or water sample, placing it in an air-tight container, and withdrawing a vapor sample for analysis using a portable field instrument. The most common headspace analyses involve using a Flame Ionization Detector (FID), a Photo Ionization Detector (PID), or a Field Gas Chromatograph (GC).

There are two general types of headspace analysis methods: "static" and "dynamic." In the "static" methods, the sample is kept stationary for a period of time to allow volatilization of organic compounds before analysis. In some cases, the sample may be heated, for example, in the heated cab of a vehicle to promote volatilization. The "dynamic" method involves agitating the sample container to further promote volatilization of organic compounds in the sample.

Several environmental factors may adversely affect the performance of headspace analysis: 1) high soil moisture, 2) high organic and clay levels in soil, 3) dissolved organics in water, and 4) the age or degree or weathering of the contaminant. These factors all affect partitioning of volatile constituents from the sample into the headspace.

Polyethylene Bag Sampling System

This method is a headspace screening technique using a re-closeable polyethylene bag along with a PID. A water or soil sample is collected into the chemically inert and collapsible bag. The bag is then agitated for a period of time. One the VOCs in the water or soil volatilize into the headspace of the bag then the headspace concentration is measured with the PID. As the PID withdraws air from the bag, it collapses while maintaining a constant internal pressure. This methodology tends to produce fairly reliable field screening data of VOCs.

Immunoassays

Immunoassays area relatively new technology for evaluating quantitative or semi-quantitative hydrocarbon contamination, originally developed for testing for the presence of agricultural pesticides. Test kits are based on colorimetric analyses such that the concentration of organics is proportional to color change. Tests are relatively quick and easy to perform; five samples can be taken and analyzed in about 20 minutes. They are convenient, accurate and cost effective.

Because of the complexity, time and expense required in developing kits, manufacturers have designed them to recognize and quantify groups of hydrocarbon compounds. Consequently, no kits have been developed for recognizing individual compounds. There are many kits available for use in the environmental industry. Ones available for use at LUST sites have been developed for PAHs, TPH, and BTEX and are capable of measurements ranging from about parts per billion (ppb) levels to 10,000 parts per million (ppm).

Immunoassays are relatively easy to use. However, if improperly used the data obtained may not be representative of contamination at the site. The test requires careful control of temperature, pH, and time allowed between starting the test and measuring the color response.

The advantages of the immunoassay method are that real time data is available, it is cost competitive and the results can be reliable with proper QA. For adequate QA, appropriate standards, blanks (methanol, matrix, and field); spikes (methanol, matrix, and field), and replicates (each site) are necessary.

Studies have shown that immunoassay kits are biased towards false positive identification (i.e., detection of analytes that are not truly present). Manufacturers have acknowledged this and claim it is done to prevent false negatives (i.e., no detection of analytes that truly are present). This was presumably done to minimize the occurrences of a worst case scenario (i.e., false negatives).

Soil Gas Surveys (SGS)

SGSs are primarily used for detecting and mapping low molecular weight halogenated solvent compounds and petroleum hydrocarbons possessing high vapor pressures and low aqueous solubilities. Therefore, they are ideal for detecting highly volatile organic compounds such as benzene and trichloroethylene.

If SGSs are conducted with a FID, PID or other technique, laboratory analytical soil samples are required to confirm the extent and magnitude of soil contamination in the vadose zone. Analytical samples require collecting soil borings or soil gas samples and analyzing them in the lab with a GC or a gas chromatograph/mass spectrometer (GC/MS). If the results of the field screening and analytical results confirm that contamination is likely to be localized in a shallow unsaturated zone, then push probes may be used to collect subsurface analytical samples. Push probes can be incorporated into all soil gas sampling procedures and used as collection devices.

Push probes should be driven in a manner as to limit atmospheric short circuiting. Readings in an area should be taken from similar depths for comparative purposes (i.e., readings from depths of 3, 6 or 9 feet, etc. Probes should also be advanced to the depth of the capillary fringe and samples be collected as close to the water table as possible. A minimum of 5 volumes of air should be evacuated prior to sample collection. Samples collected should be analyzed by approved laboratory analytical methods (Chapter 5) or by an approved field GC.

Colorimetric Tubes

Colorimetric tubes have been designed for measuring concentrations of specific gases and vapors. The principle behind their use is the gas or vapor is drawn through a tube by a pump and reacts with the indicator chemical in the tube. When the two compounds react with each other, a colored stain results whose length or amount of color change is proportional to the gas/vapor concentration. The most commonly used colorimetric tubes in the industry are manufactured by Hanby and Draeger.

The tubes normally read directly in ppm or in percent (%) from a scale on the tube. Some tubes have scales in millimeters (mm). With that type tube, the length is read in mm and referenced to a standard for that particular tube of study. Although the tubes come from the factory calibrated, the pump must be checked and calibrated regularly to verify the flow rate and sample volume per pump stroke.

The tubes are very easy to use and require little training to learn how to use properly. However, they are only accurate within about +/-25%.

3.4 Selection of Appropriate Field Screening Tools

The process of selecting an appropriate technique begins with determining the purpose of field screening. The tables following this discussion (Table 3.1 through 3.5) should be used to decide the proper instrument and field screening technique based on the desired application, performance factors, and analytical performance. Tables 3.1 and 3.2 have scales of suitability relative to other methods listed on the table. Comparisons are based on many factors including ease of use, cost, precision, accuracy, speed and detection limits.

Table 3.1
Applications of Field Measurement Procedures

Procedure	*Media*	*Confirm Presence of Contamination*	*Quantify Contamination Level*	*Identify Source of Highest Contamination*	*Determine Placement of Monitoring Wells*	*Determine Limits of Soil Excavation*	*Measure Groundwater Remediation Progress*
General Headspace Analysis	Soil, Water	High	Low	High	Medium	Medium	Low
Bag Sampling	Soil, Water	High	High	Medium	Medium	High	High
Immunoassay	Soil	High	Medium	Low	Low	High	High
Soil Gas Survey	Soil, Water	High	Low	Low	High	Not Applicable	Not Applicable
Colorimetric Tubes	Soil	Medium	Low	Low	Not Applicable	Low	Not Applicable

Table 3.2
Field Procedures Performance Factors

Procedure	*Media*	*Skill Level Required*	*Lab and Field Correlation Data Available*	*Interference From High Clay Content*	*Interference From High Soil Moisture*	*Interference From High Organics*
General Headspace Analysis	Soil, Water	Low	No	High	Medium	High
Bag Sampling System	Soil, Water	Medium	Yes	Low	Low	Low
Immunoassay	Soil	High	Yes	High	High	Medium
Soil Gas Survey	Soil, Water	Medium	Yes	High	High	High
Colorimetric Tubes	Soil	Low	Yes	Low	Low	Low

Table 3.3
Analytical Methods and Device Performance

Procedure	Measure Device	Lower Detectin Limits (LDL)		Estimated Time for Sample Collection & Analysis (min)
		Soil & Water (ppm)	Soil Vapor (ppm)	
General Headspace Analysis	FID/PID GC	10's – 100's ppb	NA	10-20 20
Bag Sampling System	FID/PID GC	1 ppb	NA	10-20 20
Immunoassays	Colorimetric Plates	1 ppm	NA	5-30
Soil Gas Survey	FID/PID GC	NA	10's – 100's Ppb	10-30 15-35
Colormetric Tubes	Detector Tubes	10ppm	Not Applicable	5-10

Table 3.4
Summary of Analytical Device Performance

Analytical Device	Skill Level Required	Calibration Frequency	Ease of Maintenance	Operation Factors
FID	Medium	103 times every day	Easy	-Detects methane -Low oxygen levels cause flame out -Ambient air must be >40°F -Hydrogen gas is required -Low flow rate may produce unreliable readings
PID	Medium	1-3 times every day	Very Easy	-Lamp requires periodic cleaning/charging - High relative humidity (>90%) "quenches" signals - Interference from dust particles, nearby AC or DC lines, high voltage radio wave transmitters - Less accurate when concentrations >150 ppm
Field GC	High	5-10 Samples	Difficult	- Operates under limited temperature range - Requires experienced technician
Immunoassays	High	With each run	Easy	-Sensitive to soil heterogeneity - May be quantitative or semi-quantitative - Limited shelf life - Requires experience technician
Colorimetric Detector Tubes	Low	None	None	-Limited shelf life - High humidity can reduce sensitivity

Table 3.5
Characteristics of Survey Instruments (PID, FID)

Characteristic	PID	FID
Response	Responds to many organics and inorganics depending on the ionization potential of the analyte and the choice of lamp (9.5eV, 10.2eV, 11.7eV.)	Responds to most organics. Will not respond to inorganics. Methane response is often a source of interference.
Response Time	Very rapid. Appproximately 3-5 seconds to 90% reading	Depends on mode of operation: Survey mode – rapid response. (approx. 3 sec) GC mode – fast to slow based on column retention time
Compound Specificity	Not specific in unknown atmospheres.	Survey mode – not specific. GC mode-can be specific depending on choice of columns and interferences present.
Ease of Operation	Very easy.	More complicated, well trained sampler required.
Reliability	Very good.	Very good.
Durability	Very good.	Excellent.
Maintenance	Clean lamp. Recharge battery.	Requires periodic preventive maintenance. Refill hydrogen supply, change battery.
Calibration	Easy, secondary calibration.	Survey mode - easy, secondary calibration. GC mode - more difficult. Requires primary calibration in order to be used quantitatively for specific components.
Best Application	Survey instrument providing approximate concentration values. Can provide fairly accurate concentration values if the analyte is known.	Survey mode – provides concentration of total hydrocarbons. GC mode – varying degree of potential as a specific component detector and quantifier. (e.g. chloroform, 15ppm minimum detectable level. Benzene 70 ppb detectable level).
Weather	Does not respond well in very humid conditions such as rain or very cold temperatures.	Responds well in most weather except very cold temperatures.

Results from different screening techniques are not directly comparable. To increase reliability, it is recommended that the same instrument be used each time with the same calibration standard or in the case of the PID using the same lamp strength throughout the investigation. In addition, a combustible gas indicator and an explosimeter should always be on hand for health and safety reasons especially in confined spaces.

3.5 Sampling Procedures Pertinent to All Screening Techniques

Upon arrival in the field, delineate all cultural interferences (i.e., buried utilities, piping, overhead power lines). This can be visual observation, with maps depicting the locations of interferences, or contact with utilities such as Dig Safe. Once the interferences have been found, they should be marked with spray paint or surveyor's tape for future reference and to avoid intercepting pipes or utilities when installing soil borings, probes, excavating walls, trenches or test pits.

Soil samples should be collected to confirm the degree and extent of contamination of soil in the unsaturated zone. Analytical samples consist of collecting soil borings or soil gas samples and have them analyzed in the lab with a GC or a GC/MS. See section 4.4 – Soil Sampling. The results are used to confirm the presence of contamination as determined by field screening.

Initial borings/test pits should be conducted near the potential source or in the zone of known contamination. Subsequent sampling should proceed radially outward or along the boundary of contamination until the extent of contamination is defined in the horizontal and vertical dimensions.

Chapter 2 should be consulted for a complete discussion on choosing the number and location of sampling points. The number of borings/test pits will depend on, amongst other things, the size of the source area and site, the age of the spill/release, depth to groundwater, the complexity of the geology or hydrogeology and size of the site.

At a minimum, vertical field screening intervals should occur:

1) at a minimum of every 5.0 vertical feet per boring/test pit in any major soil type;

2) at every change (visual or odor) in soil type; and

3) directly above the water table.

It is important to look for lenses of finer grained materials in stratified soils, as they may redirect the migration of vapors and product in the unsaturated zone. The spacing between borings should be such that no more than 20 feet separates borings/test pits intersecting soils with low contamination detects from borings with no detect.

3.6 Report Format

Results from field screening of soil, water, or air samples shall be documented in field data sheets similar to Figure 3.1, which is an example soils field data sheet. The data will be condensed into tabular form with a description of the sample site or designation and the reading from the instrument(s). A short concise interpretation is also required. Interpretation may include but is not limited to extent and location of contamination, migration direction, theories on when the spill/release occurred, and location of the spill/release. See the example form given in Figure 3.6.

A site plan should also be included in the documentation. The site plan should include all of the sample points used in the field screening. If a vertical profile was taken of the soil gases, a table consisting of all soil data locations and field screening results shall accompany the site plan. Subsequent laboratory data analyses should be provided in a separate table and submitted at the same time, including supporting laboratory data sheets. Weather conditions, copies of color photographs of soil samples and their location if appropriate, the type of field screening techniques used, and an isoplot of contaminant concentrations should also be part of the documentation.

Copies of all documents produced from all screening methods are to be submitted as part of the IRA/ISC or SI.

Figure 3.1
New Hampshire Department of Environmental Services
Field Screening Parameters
Soils Field Data Sheet

Client Name: _____ Project Number: _____

Facility Name: _____ DES Site #_____

Location: _____

Facility Type: _____Date: _____

Weather Conditions: _____

_____

Samplers: _____

Sample Location	Sample Depth	Time	VOCs (ppm)	Lab Sample (Y/N)

TPHs: Total Petroleum Hydrocarbons
VOCs: Volatile Organic Compounds
PAHs: Poly-aromatic Hydrocarbons

Interpretation/Notes: _____

_____

_____

_____

_____

Instrument: _____ Calibrated by: _____

Calibration Date: _____ Calibration Method/Gas: _____

Note: Use reverse side for field sketch if necessary.

Chapter 4

Sample Collection, Preservation and Storage

4.1 Introduction

The most critical portion of performing remediation at a contaminated site is to collect, store and preserve samples that are genuinely representative of the contamination at the site. In order to collect representative samples, proper procedures must be followed. This chapter outlines those procedures that are acceptable to NHDES for sampling, storing and preserving samples. NHDES soil and groundwater standards are presented in the RCMP revised April 2001.

4.2 Types of Samples

Type I – Grab

A grab sample is a discrete aliquot that is representative of one specific sample site at a specific point in time. Since the entire sample is collected at one particular point at one instant in time, a grab sample is representative only of those static conditions. If the source or condition is fairly consistent over a period of time and/or geographical area, the grab sample can be considered to be fairly representative assuming proper QA/QC has been followed. However, for sources that vary over time, distance, or area (e.g., release of contaminants into moving water or air), the representativeness of a grab sample is not as great.

Type II – Composite

A composite sample is a non-discrete sample composed of more than one specific aliquot collected at various sampling points and/or at different times. Composite samples give an 'average' concentration or composition over time or area.

4.3 General Sampling Techniques

1. In general, sampling techniques should emphasize the minimum handling of soil and water. This includes reducing or eliminating any unnecessary stirring, mixing or other exposure to the atmosphere.

2. Samples should be collected rapidly and placed in the recommended sampling vial or bottle.

3. If possible, add necessary preservatives before entering the field. If preservatives are added in the field, add them quickly and then cap the sample jar. See Chapter 5 for discussion on proper preservatives.

4. The sample vial or bottle should be places in a cooler on ice/freezer packs and cooled to 4^{o}C. Care should be taken to ensure that soil samples are properly sealed in a manner such that there is no debris on the threads of the vial or cap.

5. Water samples should be stored with zero headspace when the analysis is for VOCs.

4.4 Soil Sampling

Introduction

The first medium that a spill/release contacts at a contaminated site is usually soil. Contamination that has been released into the soil can be detected via two methods: soil vapor (gas) surveys and physical sampling. With surveys of soil gases, volatile compounds can be detected and measured with many field screening instruments (Chapter 3). Physical soil samples and lab analysis is used to look for possible contamination and also to categorize the geology of the area.

Physical Soil Sampling

Many devices are available for collecting physical soil samples (Table 4.1). Some samplers are used for sampling in pits or trenches and others are used for sampling at discrete depths. Some questions that should be asked to aid in choosing the appropriate sampling method are:

1. Where will the samples be taken (pit, trench, or cores)?
2. How accessible is the site? Can a drill rig mounted on a truck reach the site or is it accessible only by foot?
3. What compounds are to be analyzed?
4. What type of soil is expected at the site?
5. Will soil logs be necessary?

After soil samples are collected, many of them require some form of preservation in order to preserve the integrity of the analytes in the sample. Preservation procedures are discussed in section 4.9 of this manual. If possible, any preservatives that are used should be added to the sampling vials by the lab or before going in the field.

Tables 4.1, 4.2 and 4.3 should be consulted when determining the appropriate tool for sampling soil. The tables should be used together when formulating a decision. For example, if VOC samples are required from shallow depths, then several sampling options are possible, including, spoons, augers, and split tubes. But, Table 4.2 indicates that the spilt or solid tube is best for sampling VOCs and that augers and spoons are not preferable.

Soil Sampling Procedures at an Excavation

The procedure outlined below is a general outline of steps that must be performed for sampling contaminated soil during excavation. The purpose is to 1) analyze the quality of the remaining soil, 2) properly segregate it and 3) compare analyzed results to soil cleanup standards. Step IV has separate cases for shallow techniques and deep sampling corners.

Step I – Determine Number of Samples

To adequately characterize a site, a certain number of samples are required. Chapter 2 details procedures on determining the number and location of samples. However, Env-Ws 412 may be consulted to get an initial estimate of the number of samples required.

Step II – Sample Location at Excavation

Refer to Env-Ws 412.14 "Soils Destined for Off-Site Treatment" for procedures regarding collection of soil samples.

Step III – Screening of Samples

If samples are collected from test pits, the soil should also be screened with a PID/FID immediately after being brought to the surface to determine the location and thickness of the contaminated soil column and to segregate the soil for treatment or return to the excavation pit (See Chapter 3).

Screening should be conducted throughout the run of the test pit until contamination based onsite specific screening conditions are no longer encountered or the approximate limit of the excavation is reached. Contaminated soil from each test pit shall be segregated, temporarily stockpiled and sampled in accordance with NHDES Env-Ws 412.14 "Soils Destined for Off-Site Treatment" procedures for sampling stockpiled soil.

Step IV – Collecting Samples From Wall or Base of Excavation

Refer to Env-Ws 412.14 "Soils Destined for Off-Site Treatment" for collection of soil samples.

Table 4.1
Comparison of Soil Sampling Equipment

Sampling Device	*Applications*	*Limitations*
Spoons and Scoops	• Surface soil sampling from the sides of pits or trenches	• Limited to relatively shallow depths
Hand bucket auger	• Sampling from depths of 3-40 inches • Relatively fast sampling method	• May not retain dry, loose or granular material • Destroys the structure of cohesive soil • Cannot be used to collect samples for core analysis • Should not be used for collecting samples for VOC analysis
Power Auger	• Used to bore holes 20-25 ft when hand auguring is not feasible, a hand auger is typically used to collect the sample • Reduces sampling time	• High initial cost • Potential for sample contamination • More rigorous decontamination procedures required • Cannot be used in rock soils • Difficult to bore through rocky or tightly packed soil
Soil coring samples	• Excellent for collecting core samples for VOC analysis • Provides core samples similar to those of the soil coring device	N/A
Silver-bullet sampler	• Serrated bit allows it to bore through rocky or tightly packed soil	N/A
Split spoon sampler	• Can reach greater depths than the soil coring device Collects representative samples from a large range of depths • Ideal for collecting split samples, VOCs and geologic data • Provides relatively undisturbed core samples • Used to collect geologic data	• Require a drilling rig for obtaining deeper samples • Cannot retain loose and watery soils • Cannot be used in rocky soils
Shelby Tube	• Inexpensive • Tube may used to ship the sample without disturbing it • Modification of standard split-spoon sampler • Releasable tip allows split spoon samplers to be collected without drilling • Amount of soil cuttings generated greatly reduced	N/A
Cone penetrometer	• Collects shallow subsurface samples for detailed study of soil characteristics	• Not cost effective • Sampling results not reproducible
Backhoe	• Should only be used when attempting to find hot spots or buried wastes • Relatively fast sampling method	• Presents serious health and safety risks
Direct Push Microwells	• Collects representative sample from a large range of depths • Relatively non-intrusive	• Difficult to push through rocky or tightly packed soils

Table 4.2
Evaluation of Soil Sampling Tools

	Scoop	Hand Auger	Slide-Hammer	Open-Tube	Split-Tube/ Solid-Tube	Thin-Walled Tube
Laboratory Analysis						
Volatiles	2	2	1	NR	1/1	NR
Semi-Volatiles	1	1	1	NR	1/1	NR
Primary Metals	1	1	1	NR	1/1	NR
TPH	1	1	1	NR	1/1	NR
Sample Type						
Grab	1	NR	1	1	1/1	1
Composite (Vertical)	NR	1	1	NR	1 / 2	NR
Composite (Areal)	1	2	2	NR	2/2	NR
Sampling Depth						
Surface (0.0-0.5 ft)	1	1	1	1	NR	NR
Shallow (0.5-5.0 ft)	NR	1	1	1	1/1	1
Lithology Description	1	1	2	1	1 / 2	NR

1 – Preferred 2 – Acceptable NR – Not Recommended Source: Brynes, 1994

Table 4.3
Criteria for Selecting Soil Sampling Equipment

Type of Sampler	Obtains Core Samples		Most Suitable Core Samples		Operate in Stoney Soils		Most Suitable Soil Moisture Conditions			Relative Sample Size		Labor Requirements (persons required)	
	Yes	No	Cohesive	Not Cohesive	Yes	No	Wet	Dry	Int	Small	Large	1	2/more
Drill Rig Sampler													
Multipurpose Drill Rig	X		X	X	X		X	X	X		X		X
Split-barrel Drive Sampler	X		X		X			X			X		X
Thin-Walled Tube Sampler	X		X			X			X		X		X
Hand-held Power Auger		X	X		X			X			X		X
Hand Operated Samplers													
Screw-Type Auger		X	X			X	X			X		X	
Barrel Auger													
Regular		X	X		X				X	X		X	
Tube-Type Sampler													
Soil Sampling Tube –Wet Tip	X		X			X	X			X		X	
Soil Sampling Tube-Dry Tip	X			X		X	X			X		X	
Geoproge	X		X		X		X	X		X		X	

4.5 Groundwater Sampling

Introduction

Whenever there is a release of a regulated contaminant to the environment, there is a possibility of contaminants migrating into the groundwater. Migration is possible through the transport mechanism of water percolating or contaminants migrating through the soil. The rate of migration is controlled by soil physical properties such as pore size and geochemical properties such as the distribution coefficient (K_d) and the organic carbon content. Once contaminants reach the groundwater, they commonly disperse into the saturated formation. Depending on their physical and/or chemical properties, contaminants may be in the form of free product and can concentrate near the top (i.e., LNAPLs) or bottom (i.e., DNAPLs) of the aquifer, or they may distribute themselves (i.e., dissolved) throughout the aquifer. The proper installation and development of a monitoring well is critical to obtaining representative groundwater samples.

Measuring Depth to Water and Total Well Depth

Observation and monitoring wells may be used to measure static water levels. Levels obtained may be used to construct a water contour map.

Water level measurements shall be taken in all monitoring wells to determine the elevation of the water table or piezometric surface. The measurements shall be taken after the wells have been installed and developed and their levels have recovered completely. If a conventional well has been installed, the water table should be stabilized for at least 24 hours before any measurements are taken. If the well is installed in fine soil, the stabilization period may be less than 24 hours due to less disruption of the surrounding ground during construction. Any conditions that may effect water levels shall be recorded in the field log. Groundwater levels shall be measured to the nearest 0.01 foot. Note that if the casing cap is air tight, allow time prior to measurement for equilibration of pressures after the cap has been removed. Typically, newly installed wells should be allowed to stabilize for a period of two weeks prior to sampling.

Groundwater Purging and Sampling Equipment

Groundwater may collect in monitoring wells between sampling events and become stagnant. To obtain samples that are representative of the formation, it is a generally recognized practice to purge the standing water in a monitoring well prior to sampling. In most cases, the device used to purge the well is also used to collect the sample, however, there are times when different devices are used.

There are many factors to be considered prior to selecting a purging or sampling device for use in a monitoring well. For example, the purging device must be capable of delivering a

substantial sample volume to expedite the process. The sampling device needs to have a low enough flow so as to not agitate or aerate the sample but still efficiently fill a sample bottle.

1. Well diameter – The availability of sampling equipment is limited for small diameter equipment.

2. Portability of equipment – Remote locations of some monitoring wells require that the sampling device and accessory equipment (hose reels, battery packs, compressed air source, etc.) be highly portable. Some sampling devices require accessory equipment that must be vehicle mounted, thus reducing its portability.

3. Ease of operation – Studies have found that inaccurate results can occur from sampling mechanisms effects alone. This is a direct result of poor precision stemming from actual operating conditions during sample collection.

4. Ease of maintenance – Field operation efficiency dictates that equipment problems must be able to be solved in the field. Some devices are too complex for field maintenance because they require expensive time consuming repairs.

5. Initial and operation costs – Both the initial and capital cost and the operational and maintenance cost of sampling equipment are important considerations in a monitoring program design. Some initially inexpensive equipment may require the use of considerable amounts of compressed gas, which could be expensive.

In general, the ideal sampling device is:

1. Durable and able to withstand potentially hostile environments,
2. Inert or non-reactive with measured water quality parameters,
3. Able to deliver a sample to the surface without causing chemical or physical alterations,
4. Capable of flushing the well of stagnant water,
5. Able to deliver an adequate volume of sample for analysis,
6. Easy to operate and/or install under field conditions,
7. Easily disassembled for cleaning and maintenance,
8. Able to fit inside the well and not become lodged in wells that are not plumb,
9. Portable and easily operated in remote locations with its own power source,
10. Economical, both initially and during operation, and
11. Reliable in the field.

Nielson and Yates (1985) developed tables ranking potential purging and sampling materials from most to least desirable. Table 4.4 serves as a guide in evaluating the appropriateness of material being considered for a sampling effort. Glass is not included because of its fragile nature despite being very inert.

Table 4.5 lists the different means available for purging and sampling groundwater. Table 4.6 lists the appropriateness of the sampler for the analyte to be sampled.

Table 4.4
Materials for Use in Groundwater Purging and Sampling Devices

Rigid Construction	*Desirability*	*Flexible Construction*
Teflon	MOST	Teflon (most inert)
Stainless Steel 316		Polypropylene
Stainless Steel 304		Flexible PVC/Linear polyerthylene
Polyvinyl chloride		Viton
Low-Carbon Steel		Conventional polyethylene
Galvanized Steel	LEAST	Tygon
Carbon Steel (least inert)		Silicon/Neoprene (least inert)

Source: Nielson and Yates, 1985

Table 4.5
Comparison of Sampling Devices for Small Diameter Monitoring Wells

Device	Minimum Well Diameter	Maximum Sampling Depth	Typical Delivery Date	Flow Control	Construction Materials	Potential for Chemical Alteration	Ease of Operation, Cleaning and Maintenance
Suction-Lift	0.5”	26ft	Highly Variable	Good	Highly Variable	High-Moderate	Easy
Bailers	0.5”	Unlimited	Variable	N/A	Any	Slight-Moderate	Easy
Syringe	1.5”	Unlimited	0.2gal	N/A	SS 316, Teflon, Glass, Polyethylene	Minimum-Slight	Easy-
Gas Displacement	1”	300ft	0.2gpm	Fair	Teflon, PVC, Polyethylene	Moderate-High	Easy
Bladder	1.5”	400ft	0.5gpm	Good	SS 316, Teflon/Viton, PVC, Silicone	Moderate-Slight	Easy
Electric Submersible	2”	200ft	0.5gpm	Poor	SS 304, EPDM, Telfon, Viton	Slight-Moderate	Moderately Difficult

Table 4.6
Evaluation Table for Groundwater Sampling Methods

	Bailer	Bomb Sampler	Bladder	Piston	Peristaltic	Syringe	Electric Submersible
Laboratory Analyses							
Volatiles	2	2	1	2	2	NR	2
Semi-Volatiles	1	1	1	1	2	NR	1
Primary Metals	1	1	1	1	2	NR	1
Pesticides	1	1	1	1	2	NR	1
PCBs	1	1	1	1	2	NR	1
Radionuclides	1	1	1	1	2	NR	1
Sample Type							
Grab	1	1	1	1	2	NR	1
Composite (Vertical)	NR	1	2	2	2	NR	2
Integrated	2	2	1	1	2	NR	1
Sampling Depth							
Shallow (0.0-30.0ft)	1	1	1	1	2	NR	1
Deep (>30ft)	2	2	1	1	2	NR	1

1 – Preferred Method 2 – Acceptable NR – Not Recommended

Table 4.7
Volume of Water Contained in a One Foot Section of Well Casing

Inside Well Diameter (inches)	*Volume of Water*		
	Fluid Ounces	*Gallons*	*Milliliters*
1	5.21	0.04	154.4
1.5	11.81	0.09	349.3
2	20.89	0.16	617.8
3	47	0.37	1389.9
4	83.51	0.65	2471

Source: Wisconsin DNR, 2/87

Well Purging

Since water standing in a monitoring well is usually not representative of in-situ groundwater, it must be purged (removed) before a sample is taken. Standing (stagnant) water in a well can be affected by; leaching or adsorption of compounds on the well casing or screen, depletion of heavy metal species precipitated by sulfide, precipitation or dissolution of certain metals due to changes in the concentration of dissolved gases such as oxygen or carbon dioxide and the addition of foreign materials from the top of the well.

There is no single method appropriate for purging all wells. The method chosen for purging should be based on engineering judgment and takes into consideration aquifer characteristics. However, all purging requires similar initial steps as given below.

Step I – Well Volume Calculation

The NHDES typically recommends that between three and five well volumes be purged.

1. Use one of the above discussed procedures to measure the depth to water and by either measuring the length of the well or by reviewing the drill logs, determine the length of the water column.

2. Measure the diameter of the well in feet.

3. To calculate the volume of water standing in the well, use the equation below or Table 4.8 which indicates the volume of water in a per foot section of well casing. To calculate the well volumes, multiply the well volume by the number of volumes to be purged.

$$V(ft^{3)} \cdot \left[p \cdot \left(\frac{D(ft)}{2} \right)^2 \cdot H \right)(ft) \Bigg] \cdot N$$

Where: V = Total volume of water needed to purge (ft^3)
D = Inside diameter of well (ft)
H = Height of water column in well (ft) (depth to bottom minus depth to water)
N = Number of Well Volumes to Purge

Step II – Determine Pumping Rate

Every reasonable effort must be made to keep pumping rates low to avoid over pumping or pumping the well dry.

1. Pump rates may be adjusted to remove the required volume in a timely manner. As a general rule, the purge rate should range between 1 to 5 gallons a minute. For additional guidance, Table 4.8 may be consulted.

2. The evacuation rate of a monitoring well should not exceed that induced during the development of the well. Doing so could alter the hydrogeologic properties of the aquifer in the vicinity of the well.

3. In some situations, evacuation of 3 to 5 well volumes may not be practical in wells with slow recoveries. If a well has been pumped to near dryness at a rate of less than 0.5 gallons per minute, the well should be allowed to recover to a volume sufficient for sampling. If necessary, sampling outside of the two hour limit may be exceeded to allow the well to recover sufficiently for sampling.

Step III – Purging Inlet Location

The position of the pump (or bailer) intake is an important factor to consider when purging or sampling. The flow patterns established by different intake positions of the purging device will determine the strata from which a groundwater sample is collected.

Wells should not be pumped from below the level at which groundwater enters the well or from the strata which is to be sampled. Water entering the well from the top of the screened area will fall into a pumped dry well. This cascading effect may aerate the groundwater to be sampled, thus resulting in the loss of VOCs. Purging to dryness can cause dehydration of the saturated zone and volatiles may be lost due to aeration within this zone. Additionally, other contaminants may absorb to formation materials where a dehydrated zone is created.

The bailer or inlet line should be placed in the same position each time it is lowered into the well.

There are many circumstances where a well screen will not intersect the water table: wells screened for collection of depth discrete groundwater samples, bedrock wells with several water-bearing zones, and very slow recovering wells. In these circumstances, the well must not be purged at a rate which allows the groundwater level to fall below the zone where water enters the well. If a well is purged to dryness or below the well screen, samples should not be collected until the entire screen is covered by formation water. This should also be documented since the sample's integrity may be severely altered.

Table 4.8
Maximum Recommended Purging Rate Based on Monitoring Well Screens

Screen Type	*Diameter (in)*	*Slot (in)*	*Open Area (ft2/ft)*	*Open Area (%)*	*Recommended Pumping Rate*		
					gpm @ 0.1 ft/s	*gpm @ 0.07 ft/s*	*gpm @ 0.03 ft/s*
PVC (machine slot)	2	0.01	0.018	3.4	0.804	0.563	0.241
		0.02	0.033	6.4	1.496	1.047	0.449
		0.025	0.042	8.0	1.870	1.885	0.561
		0.04	0.060	11.5	3.385	2.369	0.808
		0.051	0.075	14.4	3.385	2.369	1.015
	4	0.01	0.036	3.4	1.608	1.126	0.482
		0.02	0.067	6.4	2.993	2.094	0.898
		0.025	0.083	8.0	3.740	2.618	1.122
		0.04	0.120	11.5	5.386	3.770	1.616
		0.051	0.151	14.4	6.773	4.741	2.032
PVC (wound)	2	0.01	0.047	9.0	2.119	1.484	0.686
		0.02	0.089	17.0	3.989	2.793	1.197
		0.03	0.124	23.7	5.579	3.905	1.674
		0.04	0.156	29.7	6.981	4.887	2.094
		0.05	0.183	34.9	8.197	5.738	2.459
	4	0.01	0.078	7.5	3.522	2.465	1.057
		0.02	0.147	14.1	6.607	4.625	1.982
		0.03	0.208	19.9	9.350	6.545	2.805
		0.04	0.262	25.0	11.750	4.887	3.525
		0.05	0.309	29.5	13.869	5.738	4.161
Stainless Steel (wire-wound)	2	0.01	0.090	17.1	4.021	2.814	1.206
		0.02	0.157	30.0	7.044	4.931	2.113
		0.03	0.210	40.2	9.444	6.610	2.893
		0.04	0.253	48.4	11.376	7.963	3.525
		0.05	0.287	54.8	12.872	9.010	4.161
	4	0.01	0.177	16.9	7.918	5.563	2.384
		0.02	0.307	29.3	11.776	9.64	4.133
		0.03	0.410	39.1	18.388	12.872	5.517
		0.04	0.492	47.0	22.094	15.468	6.629
		0.05	0.560	53.4	25.120	17.584	7.536

Source: USEPA EPA/625/R-93/003a(5/93) with permission of Meredith and Brice 1992

Step IV – Purging Procedures

Application I – General

1. Remove well purge volumes (See Table 4.8 or Equation 4.1).

2. Purge the well by pumping with the inlet hose 1 to 2 feet below the water surface to ensure that no stagnant water remains in the well above the screen after purging.

3. Withdraw samples from within or just below the screened section of the well.

4. Introduce as little air as possible and as little turbulence into the formation as possible to prevent alteration of the samples. This is especially important when VOCs are sampled.

Application II – Wells Screened in Low Permeable Formations (i.e. wells that can be purged dry)

1. Pump or bail the well dry. Care should be employed not to lower the water level below the top of the screen if normally saturated. This is the only reliable means of removing stagnant water and replacing it with fresh water from the aquifer formation.

2. The location of the inlet line for purging must be just below the top of the screen. If the inlet line is significantly below the top of the screen, water may jet or cascade into the well screen and cause aeration of the sample, oxidation of dissolved samples, trapped air in the well screen and filter pack, and/or increased sample turbidity. After the first purge, allow the well to recover and if time permits purge the well again. However, if the recovery time is excessive, sample chemistry may be affected.

3. Collect a sample as soon as there is a sufficient volume of water in the well needed for the intended analysis. This is NOT necessarily when the well has fully recovered, but when the well screen is completely covered. It is recommended that samples be collected within three hours of purging in low yield formations.

Application III – Wells Screened in High Permeability Formations (i.e. wells that cannot be purged dry)

The United States Geological Survey (USGS) recommends purging water from a well until such time as the temperature, pH and conductivity become constant. The disadvantage with this method is that very large volumes of water may be removed from the well, which could pose disposal problems and unknown quantities of water from different formation strata may be drawn into the well and mixed. As a result, constant water quality parameters may not be obtained until long after adequate purging has been done for obtaining a representative sample.

If the USGS recommendation is used, follow the procedure outlined below. If not, purge three to five well volumes.

1. Locate the inlet of the purging device at the appropriate location in the well. Mark the position on the inlet tube where it exits on the well so it can easily be repositioned.

2. Turn the purging device on and begin purging. Adjust the flow such that there is no or minimal drawdown (general rule is about 100mL/min).

3. If the groundwater flow is high, a stream of groundwater should be directed to a small reservoir where field measurements can be taken. If the flow is low, the whole stream may be directed to the reservoir.

4. Measure the field measurements (pH, temperature, conductivity, DO) until the parameters of choice become constant.

Groundwater Sampling Procedures

1. Choose a sampling device which minimizes the potential for altering the water quality of the sample. See Table 4.6 for a comparison of sampling devices for monitoring wells suitable for the sampling event. The reader may also wish to dedicate sampling equipment for each well.

2. In many groundwater sampling events, many parameters are measured and more than just groundwater samples are taken. For example, in a typical sampling event the following checklist should be consulted to assure that all the necessary equipment is made available and loaded on the field vehicle when it leaves the office.

    a. Water level indicator – steel line and chalk or electric tape
    b. Sample containers (proper size and comparison)
    c. Preservatives, as needed
    d. Ice or ice packs and coolers
    e. Field instrumentation (i.e., PID, FID)
    f. Trip blanks
    g. Bound field logbook
    h. Sample analysis request forms
    i. Chain of custody forms and seals
    j. Sample labels
    k. Personal safety equipment (i.e., disposable gloves)
    l. Hand tools
    m. Keys to locked wells
    n. Metal analysis filtering devices
    o. Field measurement instrumentation (tem., specific conductance, pH, etc.)

p. Calculator, wristwatch, timer
q. Indelible marker
r. Calibrated bucket for purge water measurement
s. Distilled and de-ionized water
t. Laboratory grade glassware detergent
u. Paper towels
v. Stainless steel clamps
w. Sampling device(s)

3. Measure the water level in the well using the procedures outlined in section 4.5.

4. Purge the water in the well according to section 4.5. Samples should be taken as soon as the well has recovered sufficiently enough to collect enough samples for analysis or within 2 hours. This is done to minimize any interactions between the well casing and the water to be sampled.

5. The volume evacuated and evacuation rate should be recorded after purging and sampling each well.

6. To prevent cross contamination, sample the least contaminated wells first and the more contaminated wells last. If the degree of contamination is unknown, sample the upgradient wells first and the downgradient wells last.

7. Samples should be collected within 2 hours of when 3-5 well volumes were purged.

8. Transfer bottles should be used for collecting samples. In addition, it is further recommended the method of sampling be identical to all wells at a single facility.

9. Samples should be exposed to the atmosphere as little as possible. Aeration can cause dissolved metals in a reduce state at equilibrium to be shifted to a more oxidized state.

10. The order in which samples should be collected from each well, regardless of the sampling device used is as follows (sampling should occur within 2 hours of purging):

    a. Volatile organics
    b. Base neutral/acid extractables
    c. TPH
    d. Dissoloved Metals

11. Collect samples and add preservative or add preservative before filling sample bottle.

12. For VOC sampling, form positive meniscus on sample bottle and quickly seal. Check for air bubbles in the vial by turning it upside down. There should be none.

13. Label accordingly and store in a cooler at $4^{o}C$.

Sampling Domestic Wells

Procedure

1. Talk with the homeowner or tenant in advance and arrange a convenient time to conduct sampling. Obtain as much information as possible from the well owner including: depth of the well, well yield, formation in which the well is completed, screen depth and length, well construction material, diameter of casing, when and by whom the well was installed, type of filter, conditioning or treatment systems (if present), and recent water quality analytical data (if available). (see Figure 4-1)

2. Inspect the water system. Locate the well, pump and the storage tank. Determine if any treatment units such as softening, iron removal, turbidity removal, disinfection, and/or pH adjustment are installed on the system. If sampling occurs after any treatment it can lead to misleading analyses depending on the constituents of interest. Basement and outside faucets may by pass treated water.

3. Drain the household plumbing and storage tank. Running the water for a minimum of 10-15 minutes before collection is a good rule of thumb. Listen for the pump or the electric circuit to the pump to come on, indicating the plumbing is being drained.

4. Samples should be taken as close to the pumping well as possible and prior to any storage tanks or treatment systems. If a sample must be taken following a treatment unit; the type, size, and purpose of the unit should be noted on sample sheets and the field logbook. If at all possible, samples should not be taken after any treatment.

5. Home faucets, particularly kitchen faucets, usually have a screen installed on the discharge. If samples are to be taken from the faucet, the screen should be removed prior to sampling for bacteria, or for volatile organics, since the screen tends to aerate the water and some volatile organics maybe lost. Also, when sampling for bacteria, flame the end of the faucet since that area may harbor a significant bacterial population. It should be noted that homeowner's plumbing systems should not tampered with in any way, except for removal of the faucet screen with permission of the homeowner. If the screen is removed for sampling, be sure to replace it when sampling has been completed.

4.6 Surface Water Sampling

NHDES may require the collection of surface water samples from storm sewer drainage, sumps, retention ponds and stream/rivers. These samples are usually collected from biased sampling locations downstream from the potential source of contamination and are used to define upstream surface water quality and the possibility of off-site migration.

There are four methods available for sampling surface water samples: bottle submersion, dipper, extendable bottle and extendable tube. Each method can be used to collect grab, composite or integrated samples. The four methods can be used to collect a variety of samples. Table 4.9 lists each of the available methods and whether each method is appropriate for sampling the chosen analyte. Table 4.10 lists the applications suitable for each method.

Figure 4-1

WATER WELL SURVEY

DES Site #	Site Name:	Town:
Date:	Completed By:	
Resident Name: Owner / Rentor (circle one)		Tax Map Lot
Address: _____ _____ _____		Telephone: (H) _____ (W) _____
If Rental, Owner's Name and Address: _____ _____		Telephone: _____
WELL DATA		
Type: Dug /Drilled (circle one)	Depth: Yield:	Static Water Level:
Depth to Ledge:	Amount of Casing Installed:	
Driller:	Town:	Tel:
Year installed?	Access?: No/ Yes (circle one) (please sketch below)	
Any filter, conditioning, or treatment system(s)?: No/Yes (circle one) Type:		
Water quality ever tested? No / Yes (circle one)	Result available? No / Yes (circle one)	Copy Attached? No / Yes (circle one)
Comments:_____ _____ _____		

Table 4.9
Evaluation of Surface Water Samplers

	Bottle Submersion	*Dipper*	*Extendable Bottle Sampler*	*Extendable Tube Sampler*
Laboratory Analysis				
Volatiles	1	2	2	2
Semi-Volatiles	1	1	1	1
Primary Metals	1	1	1	1
Sample Type				
Grab	1	1	1	1
Composite (Vertical)	NR	NR	1	1
Composite (Areal)	1	1	1	1
Integrated	1	1	1	1
Sampling Depth				
Surface (0.0-0.5ft)	1	1	2	2
Shallow (.5-5.0 ft)	NR	NR	1	1
Deep (>5.0 ft)	NR	NR	NR	NR

1 – Recommended 2 – Acceptable NR – Not Recommended

Table 4.10
Description and Application of Surface Water Samplers

Instrument	*Description*	*Application*
Bottle Submersion	Telescoping rod, clamp and sample bottle	Shallow surface water
Dipper	SS or Teflon Dipper	Shallow surface water
Extendable Bottle	Telescoping rod and sample bottle with remote cap release	Deep surface water and discrete samples
Extendable Tube	Telescoping rod and sample bottle, remote cap release and check valve	Deep surface water and discrete samples

4.7 Field Filtering

The NHDES requires that certain groundwater samples collected from overburden monitoring wells for dissolved metals analysis be field filtered prior to laboratory analysis. Note that the NHDES does not require field filtering for samples collected from domestic bedrock wells and monitoring wells screened entirely in bedrock.

Filtering is performed for the following reasons:

- Any suspended sediment contained in the sample can react with the sample and change the concentration of some of the dissolved constituents, yielding a sample that is not representative of true groundwater quality.

- Not filtering samples before adding acid preservation causes absorbed ions to be put into solution, yielding artificially high concentrations.

The key to obtaining filtered samples that are representative of groundwater is to minimize subjecting the samples to changes in pressure and agitation. Aeration or agitation will tend to degas the carbon dioxide and dissolve other gasses into the sample. Therefore, handle the samples so as to limit agitation and changes in pressure in order to maintain a representative sample.

Inorganic Compounds

Field filter all samples collected for dissolved metals and other inorganic materials analyses. Samples should be filtered immediately after collecting the sample unless the colloidal material or absorbed material in the sample is of interest. It is important to avoid aerating the sample so that dissolved metals will not be precipitated and removed from the sample.

Application I – In-line filtering

Use an in-line filter so the sample's exposure to the atmosphere is limited. If in-line filtering is not possible, include a discussion of how the chosen filtering method affects the sampling results in the QA/QC documentation.

Application II – If In-line filtering is not possible

If in-line filtering is impractical due to sampling space constraints, the sample can first be collected in a transfer container. However, in order to minimize disruption of the sample, it is recommended that transfer containers be limited whenever possible.

Application III – Use of Transfer Containers

If a transfer sample container is used, first retrieve the sample with a pump or bailer. The sample can be filtered by using a peristaltic pump or dedicated disposable syringes to draw it from the transfer container through the filter and into the sample container.

Procedure

1. Set up the filtering apparatus according to the manufacturer directions.

2. Use a 0.45 µm membrane filter, if applicable. If the sample is very turbid, you may need to use a pre-filter with a larger pore size to prevent clogging.

3. Pump the sample through the filter.

4. Collect the volume of sample needed in the sample containers.

5. For non-dedicated samplers, remove the filter membrane (and the filter if applicable) after the sample is collected and discard. DO NOT REUSE FILTER PAPER FOR ANOTHER SAMPLE. If using disposable syringes, select another one for the next sample.

6. For non-dedicated samplers, flush the filtering apparatus and tubing with 500mL reagent grade water and reassemble the filtering apparatus for next sample.

Filtering Volatile Organic Compounds

Samples collected for VOCs analysis should NOT be filtered. Filtering samples collected for VOCs would likely alter the character of the VOCs or be lost in the sample. The VOCs may be absorbed onto particulate matter in suspension or onto the filter as the sample passes through the filtering device.

4.8 Storage

Unless state otherwise, samples should be stored at 4^{0}C. This is often accomplished in the field with coolers and ice or ice packs. Samples should be labeled with waterproof markers and the seals on each of the bottles should be checked to prevent leakage.

4.9 Sample Preservation

Sample preservation for the soil samples that will be analyzed for VOCs by EPA SW Methods 8015A, 8012B, or 8260B will follow methodology outlined in the NHDES policy "Preservation of VOCs in Soil Samples, March 2000". This policy includes what is described in the ASTM Standard D4547-98 or in EPA Method 5035 and should be followed for the collection of the VOC soil samples. NHDES believes that in the vast majority of cases, samples can be collected using the following two soil preservation techniques discussed in ASTM D4547-98 and EPA Method 5035: 1) Field presentation with methanol and 2) the use of low VOC loss sampling systems such as the En Core™ sampler or equivalent. The NHDES requires the laboratory report a minimum weight estimated quantiation limit of 100mg/kg for these two methods. The complete preservation policy, including the ASTM Standard D4547-98 and EPA Method 5035, can be obtained from the NHDES.

Sample presentation techniques for water samples should follow procedures outlined in Chapters 2 and 4 of SW-846 Revision 3, dated December 1996.

4.10 Air Surveillance

Procedures for indoor air sampling are included in the NHDES Draft Remediation Indoor Air Assessment Guidance Document, which was originally revised in October 1998 and revised March 2000. A copy of the guidance document can be downloaded from NHDES's website at www.des.state.nh.us/orcb/doc/list.

Chapter 5

QA/QC and Analytical Parameters

5.1 Introduction

Even though representative samples have been collected and chilled, if applicable, the samples must still be analyzed within strict time limitations in order to assure sample integrity. Selecting a lab capable of meeting the client's objectives necessitates making sound decisions based on several parameters.

Once samples are collected they must be analyzed according to procedures approved by the NHDES. Within each of the approved procedures, experimental parameters are designed to minimize errors and optimize the validity and quality of the data.

Data Quality Objectives (DQO) specify the quality and quantity of data required to support decisions during the IRA and the SI. They are discussed in brevity in Section 5.2.

To determine whether the data that is produced during a sampling event is precise and accurate, QA/QC policies have been adopted. QA/QC policies allow the data used to determine whether the data collected is precise and accurate. QA/QC consists of blanks, duplicates, spikes, documentation of procedures, and chain of custody forms.

5.2 Data Quality Objectives

DQO's should be outlined in the Sampling and Analysis Plan (SAP). DQOs can be developed generically for a contaminated site. The following three stage process should be used.

Stage 1: Identify Decision Types

- Identify and involve data users in process
- Evaluate available data
- Develop conceptual model
- Specify objectives/decisions

Stage 2: Identify Decision Uses/Needs

- Identify data users
- Identify data types
- Identify data quality needs
- Identify data quantity needs
- Evaluate sampling/analysis options
- Review Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) parameters

Stage 3: Developing SAP

- Components of the Quality Assurance Project Plan (QAPP)
- Components of FSP

The Quality Assurance Program Plan (QAPP) should address the following primary elements (EPA, 1993):

- Sampling procedures
- Sample and document custody procedures
- Calibration procedures and frequency
- Analytical procedures
- Data reduction, validation, and reporting
- Internal quality control checks
- Performance and system audits
- Preventative maintenance
- Data measurement assessment procedures
- Corrective actions
- Quality assurance reports to management
- Decision tree for problems encountered

Many consultants already use or have a SAP, QAPP and a general FSP. A site specific FSP is the *only* plan that needs to be approved by NHDES before being implemented. Please note that all QAPPs should include the most current analytical methods and provide the most current analytical methods references.

5.3 Choosing a Laboratory

Certified laboratories must be used for groundwater, surface water and soil samples. A list of such laboratories can be obtained from NHDES. For soil sampling, NHDES will accept laboratory analysis from laboratories certified for water analysis.

5.4 Choosing an Analytical Method

Most of the accepted analytical methods for analysis are adapted from a series of EPA methods developed for either water or solid waste and published in SW-846, which may be consulted for reference.

NHDES has adopted analytical methods for analyzing water and soil samples contaminated with gasoline, diesel, motor oils, and various hazardous wastes. These methods are summarized in Table 5.1 and 5.2.

Table 5.1
Recommended Analytical Methods for Petroleum Contaminated Sites (See note 1)

Petroleum Product	Water Matrix			Soil Matrix (See note 2)		
	Analytes	Recommended Analytical Methods		Analytes	Recommended Analytical Methods	
		Initial Round	All Other Samples (See note 3)		Initial Round	All Other Samples (See note 3)
Gasoline and Similar Weight Products	VOC (see note 4)	8260B (see note 4)	8021B plus MTBE or 8260B	VOC TPH as Gasoline	8260B (see note 8) 8015B-GRO (see note 8)	8021B plus MTBE or 8260B (see note 8) 8015B-GRO (see note 8)
No. 2, 4, 6 Fuel Oil Diesel Waste Oil (see note 5) and similar Weight Products	VOC (see note 4) PAH (see note 6)	8260B (see note 4) 8310 or 525 or 8270 (see note 7)	8021B or 8260B 8310 or 525 or 8270 (see note 7)	VOC PAH (see note 6) TPH-as Fuel Oil As, Ba, Cd, Cr, Pb, Hg, Se, Ag (waste oil only - see note 5)	8260B (see note 8) 8270 or 8310 8015B-DRO 6010 or 7060, 7080, 7130, 7190, 7420, 7470, 7740 cold vapor, 7760	8021B 0r 8260B (see note 8) 8270 or 8310 8015B-DRO 6010 or 7060, 7080, 7130, 7190, 7420, 7470, 7740, cold vapor, 7760

VOC: Volatile Organic Compound
TPH: Total Petroleum Hydrocarbons
MTBE: Methyl-butyl ether
PAH: Polyaromatic Hydrocarbons
RCM Policy: NHDES Contaminated Sites Risk Characterization and Management Policy
P&T-GC/FID: Purge and Trap – Gas Chromatography/ Flame Ionization Detector
TCLP: Toxicity Characteristic Leaching Procedure
AGQS: Ambient Groundwater Quality Standards

Revised November 2000

Notes:

(1) EPA method results must be reported to NHDES according to SW 846 current edition.

(2) Soils destined for off-site treatment and disposal must be analyzed in accordance with Env-Ws 412.14

(3) Analytical methods used for all other samples must be able to detect all analytes discovered in the initial round. For the purpose of site closure, the analytical method from this shall be capable of detecting concentrations lower than the regulatory cleanup level.

(4) At new sites VOC analysis shall include tentatively identified compounds (TIC) for the initial sampling round. Residential and commercial OPUF sites are exempt from this sampling requirement. 8260B analysis from service station sites that were in operation post 1994 should include the following oxygenates: MTBE, TAME, DIPE, TBA and ETBE.

(5) Metals analysis must be performed on waste oil contaminated soils. Soil standards in the NHDES RCM Policy are based on total metals. Analysis for soils destined for off-site treatment are based on TCLP.

(6) PAH analysis shall be completed on all sampling locations during the initial round of sampling for soil and water.

(7) Ion-specific analysis shall be completed on all sampling locations during the initial round of sampling for soil and water.

(8) Samples collected after March 2000 for 8260B, 8021B-GRO shall use EPA 5035 or ASTM D4547-98 sampling methods.

(9) Additional field testing and laboratory analysis of geochemical indicators may be required on a site specific basis at the request of DES.

Table 5.2
Recommended Analytical Methods for Hazardous Waste Contaminated Sites

Water	**Soil Matrix**
Analytes	Recommended Analytical method
Ignitability	Ignitability Characteristic for Soil Samples (NHDES method)
Corrosivity	EPA method 9045
Reactive Sulfide	SW 846 7.3.4.1
Reactive Cyanide	SW 846 7.3.4.2
Volatile Organic Compounds	EPA method 8260B
Semi-volatile Organic Compounds	EPA method 8270C
Polychlorinated Biphenyls	EPA method 8081A
Total Petroleum Hydrocarbons	Total Petroleum Hydrocarbon Analysis (NHDES method)
Arsenic	Preparation: EPA methods 1310 Analysis: EPA methods 7060 or 6010
Cadmium	Preparation: EPA methods 1310 or 1311 Analysis: EPA methods 7080 or 6010
Chromium	Preparation: EPA methods 1310 or 1311 Analysis: EPA methods 7190 or 6010
Lead	Preparation: EPA methods 1310 or 1311 Analysis: EPA methods 7420 or 6010
Mercury	Preparation: EPA methods 1310 or 1311 Analysis: EPA methods 7470 Cold Vapor
Selenium	Preparation: EPA methods 1310 or 1311 Analysis: EPA methods 7740 or 6010
Silver	Preparation: EPA methods 1310 or 1311 Analysis: EPA methods 7760 or 6010
Endrin	EPA method 8081A
Lindane	EPA method 8081A
Methoxyclor	EPA method 8081A
Toxophene	EPA method 8081A
2,4-D	EPA method 8151A
1,4,5-TP	EPA method 8081A

5.5 Quality Assurance/Quality Control/Parameters

Field Quality Assurance and Procedures

Field QA procedures are required to maintain the physical form and chemical composition of the sample and to prevent contamination from other sources or changes in contaminant concentration. To meet these objectives, there must be a measure of control over all sample handling procedures including documentation, sample container cleaning, proper sample collection and storage and lab analysis.

To assure that data and samples collected in the field are representative and valid, proper documentation is critical including:

- Making use of a standardized field sampling form (see example at end of Chapter 3)
- Verification of sampling data by an independent authority (i.e., somebody familiar with analyzing data and all associated QA/QC protocols/data)
- Strict adherence to chain-of-custody procedures
- Documentation of instrument calibration
- QA also requires collecting samples in clean and appropriate containers and also sealing them properly so they do not leak or cause loss of volatiles

To minimize confusion and error, as much field information as possible should be completed before sampling commences. For example: all sample bottles should be properly labeled, preservatives should be added to the sample containers in the laboratory and the field book should be organized and completed as much as possible. Documentation of instrument calibration should contain at the very least: the calibration time, and date, instrument identification number, the calibration standard used, whether the calibration was successful or not, and the calibrator's signature.

Field and Fixed Lab Quality Control

On average, analytical methodology requires approximately 30% to 50% of samples analyzed be QC related. Some methods such as graphite furnace analysis for metals require that up to 80% of the injections be QC related. Despite the volume of QC data that is generated, many engineers and other data users do not know how to interpret QC results. For example, many users are not sure if the QC results that are reported indicate the data obtained is precise, accurate and valid.

PARCC Parameters

Precision, Accuracy, Representativeness, Completeness and Comparability (PARCC) are used to gage the integrity of a sample after it has been analyzed and determine the prescribed quality for the actual field and analytical methods.

- Precision is defined as the degree of mutual agreement among different individual measurements made under prescribed conditions.

- Accuracy is the degree of agreement of a measurement with an accepted reference or true value. Precision and accuracy are both affected by sampling and analytical factors. The analytical effect on precision and accuracy is more easily controlled than the sampling effect on precision and accuracy. The most common way of assessing precision and accuracy and to recognize contamination and its potential source is with the use of blanks, spikes and duplicates.

- Representativeness expresses the degree the sample represents the population parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter which is primarily concerned with the proper design of the sampling program (See Chapter 2). The criterion is most appropriately satisfied by being certain that a sufficient number of samplers are collected, and the sampling locations are carefully positioned at representative locations.

- Completeness is defined as the percentage of samples judged to be valid compared to the total number of samples collected. CLP data has been found to be 80% to 85% complete on a nationwide basis.

- Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This parameter is limited by the other PARCC parameters since data sets can be compared with confidence only when they are precise and accurate.

Table 5.3
Description of Blanks, Duplicates and Spikes

Sample Type	*Description*	*Type of Information Provided*	*Number Required*
	Blanks		
Equipment blank (field rinsate blank, decontamination blank, dynamic blank)	Used to determine if field equipment cleaning was adequate; prepared by pouring distilled/de-ionized (D/D) water over the sampling device after it is decontaminated (does not refer to dedicated equipment).	Quantifies error associated with equipment decontamination, containers, field environment, cross-contamination, and lab analysis.	Each batch of samples should include one equipment blank or 5% of total samples collected.
Field Blank	Used to determine if any contaminants present at the site have an effect on sample integrity; prepared by pouring D/D water into sampling container at certain sampling locations (typically areas where dust and/or volatile organic contamination may emanate from other sources)(may be used occasionally).	Quantifies error associated with the field environment, containers, cross contamination, and lab analysis.	5%-10% of total samples collected
Preparation rinsate blank (sample bank blanks)	Used to determine if field sample preparation (e.g., soil homogenization bowl, etc.) were cleaned properly; prepared by pouring D/D water over the sample preparation apparatus after it is cleaned (may be used occasionally).	Quantifies error associated with field sampling preparation, containers, filed environment, cross-contamination, and lab analysis.	Each batch of sample should contain one preparation rinsate blank.
Trip blank	Determines if contamination occurs during shipment. Consists of glass sample containers filled with de-ionized water at the lab. The samples are shipped to the site and sent back to the lab with routing sample; they are not opened until they reach the lab.	Quantifies error associated with shipment, containers, and lab analysis.	At least one trip blank per shipment.

Table 5.3
Description of Blanks, Duplicates and Spikes (Continued)

Sample Types	*Description*	*Type of information provided*	*Number required*
Precision Measurements			
Field Duplicate (collected samples)	Two samples collected simultaneously into separate containers from the same sampling location under identical conditions.	Estimates overall precision of sample collection, field sample preparation, and lab analysis (total within batch measurement variability). Subdividing one or both of the collected samples just prior to analysis provides an estimate of analytical precision.	5% of total samples collected; at least 20 field duplicates should be collected if precision estimate is important.
Field replicate (preparation split sample)	After soil collection and mixing, a sample is split (in the field) into 2 portions in separate containers; a routine sample and a replicate sample.	Quantifies error associated with sub-sampling (i.e., split preparation) and lab analysis; may be sent to a reference lab to check for bias or to estimate inter-lab variability.	At least 20 field replicates should be collected if it is important to assess sub-sampling and lab analytical variance; otherwise, fewer replicates are necessary.
Field Evaluation Samples	Homogeneous soil sample (similar to soil to be samples) containing a known contaminant concentration is sent to the site and handled in a fashion identical to routine samples. As an alternative, batch field duplicates can be collected.	Detects bias in entire measurement process and determines batch-to-batch variability.	N/A
Bias measurements			
Field Spike	Prepared in the field by adding a known amount of reference chemical to one of a pair of split samples. Difficult to prepare/perform and interpret results.	Comparison of spiked and non-spiked results measures analytical bias.	N/A

Table 5.4
Detection Limits and Definitions

Detection Limit	*Definition*
Instrument Detection Limit (IDL)	The smallest signal above background noise that an instrument can detect at a 99% confidence level.
Method Detection Limit (MDL)	The minimum concentration of a substance at which individual measurement results for a specific analyte are statistically different from a blank (that may be zero) with a specified confidence level (usually 99%) for a given method and representative matrix.